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**TO:** Tourist Operators / Researchers on the Great Barrier Reef

**DATE:** 21 April, 1997

**RE:** Damage to Coral Reefs from Tropical Cyclone Justin

As you know, tropical cyclones can generate large waves capable of damaging coral reefs by breaking, overturning and burying them under sediment. Tropical Cyclone Justin (March 1997) was both an unusually large and persistent cyclone, generating big seas which may have impacted the reefs of the Great Barrier Reef World Heritage Area.

As the only cyclone in recorded history to cross land at both Cairns and Townsville, and one of the largest cyclones in recent times, Justin's path criss-crossed over a large area of the Great Barrier Reef (GBR) Region. And since the cyclone also moved very slowly, big seas built up (wave heights of nearly 5 meters were recorded at Mackay) in the GBR even when the cyclone itself was 100's of km away!

Since Cyclone Justin and the waves it generated covered such a large area, visiting every reef that could have been damaged would take months! Therefore, to investigate the location and extent of reef damage from the cyclone, the Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef (CRC Reef) needs your help!

Attached is a very brief, one-page questionnaire to be completed by anyone who has visited any reef in the GBR since 24 March 1997. Reply postage on each survey is paid, so simply fold the survey when complete and mail it back to us free of charge. Please fill out a separate survey for each reef site - if you need more surveys, feel free to make copies, or contact us.

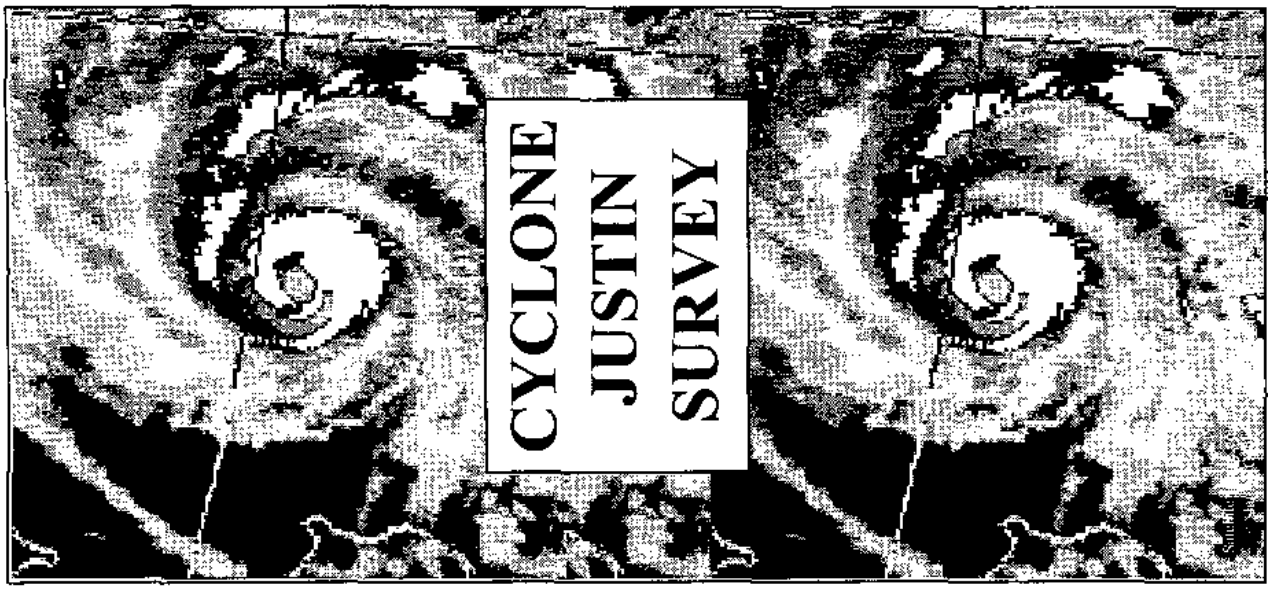
Thank you very much for your help!

Sincerely,

Marji

Marji Puotinen

*Phone:* 077-81-5566 *Fax*: 077-81-4020
*Email:* pmap@cathar.tesag.jcu.edu.au




Reply Paid 47

CRC Reef Research Centre

CRC REEF RESEARCH CENTRE
c/o James Cook University
TOWNSVILLE QLD 4811

Please circle the reef you visited on the maps provided with this survey. Make a sketch of the reef in the space below and mark the sites you visited. *Label each site* with GPS coordinates if you can.

Cyclone Justin was both an unusually large and persistent cyclone, generating big seas and huge rainfall, both of which may have impacted the reefs in the Great Barrier Reef World Heritage Area.

Thus, to investigate the extent of wave and *runoff* damage to reefs, the Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef (CRC Reef) *needs your help!*

Please take a few minutes to complete this survey for *each reef you* have visited since Monday 24 March 1997 (use a *seperate* form for each reef site).

Please mark each box with a number from 0 to 3 to describe the *extent* of damage you observed as follows:

[3] Extensive (continuous *damage - 100's* of square meters or more)
[2] Some (*patchy but widespread*)
[1] Slight (localized damage)
[0] None apparent

**DESCRIBE UNDERWATER DAMAGE**

- ☐ large coral heads overturned
- ☐ extensive tracts of recent staghorn rubble
- ☐ reef top swept clear
- ☐ evidence of sandblasting of corals and gross *sand movement*
- ☐ staghorn colonies totally demolished
- ☐ staghorn colonies with tips broken
- ☐ *large areas* of freshly killed / broken coral
- ☐ piles of freshly killed coral
- ☐ piles of rotting material (algae, soft corals)
- ☐ smell of decomposition pervasive
- ☐ new growth of algae (seaweed)
- ☐ overturned clams

Other notes.....
.....
.....
.....

**ISLAND DAMAGE**

- ☐ Erosion of sand cays
- ☐ New sand banks or *gravel banks*
- ☐ Large trees overturned
- ☐ *Leaves stripped* from trees
- ☐ Large waves (.....meters)

Compass aspect of damaged area:

☐ N ☐ NE ☐ E ☐ SE
☐ S ☐ SW ☐ W ☐ NW

Other notes.....
.....
.....

**DAMAGE TO INFRASTRUCTURE**

Did you observe damage to vessels, buoys, pontoons, moorings, jetties? ☐ Yes ☐ No
If yes, describe.....
.....
.....
.....

Reef Name.....

☐ *Reef front* ☐ Back slope ☐ Flat

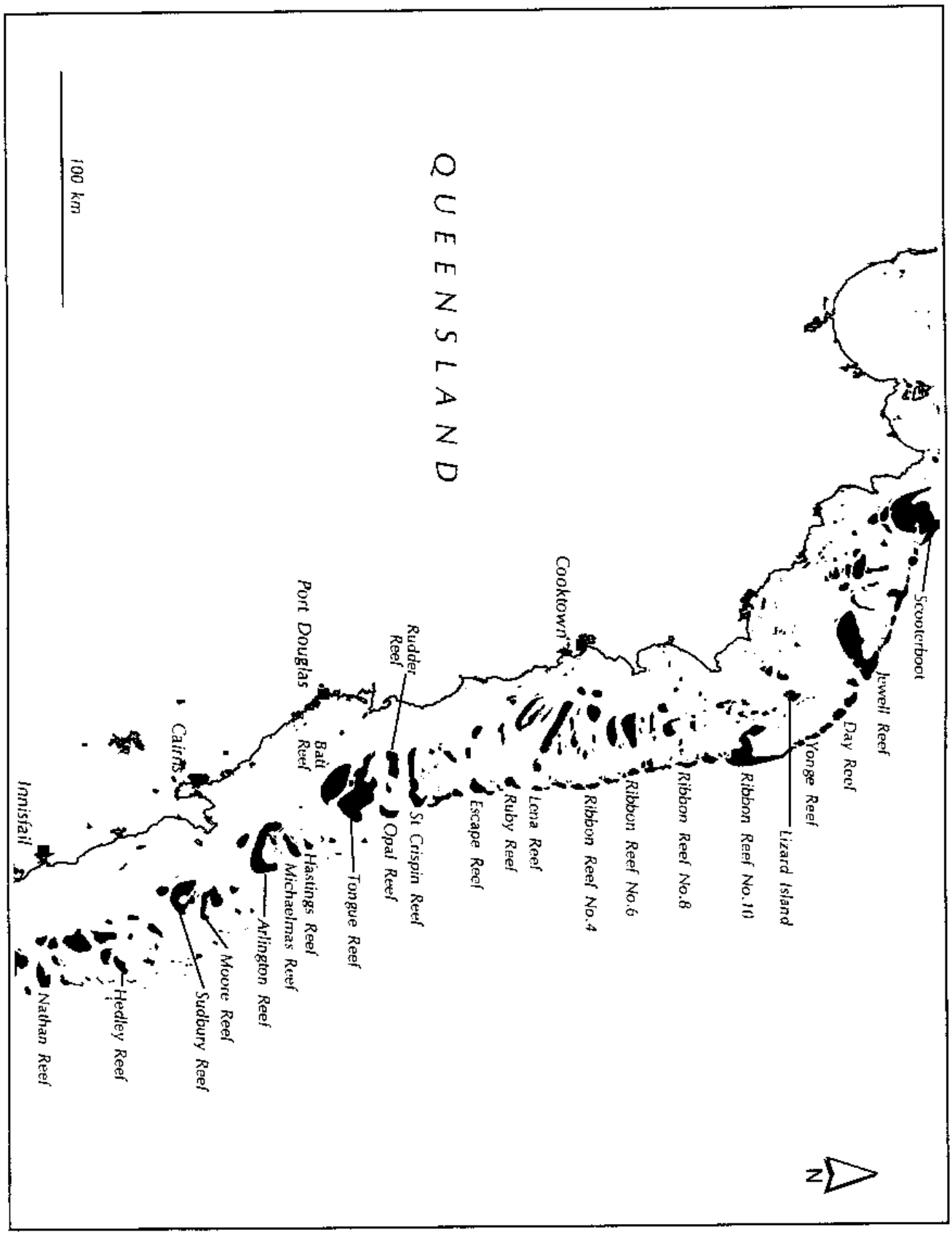
*Date you were there*...../...../.....

Your name.....
Your address.....
.....

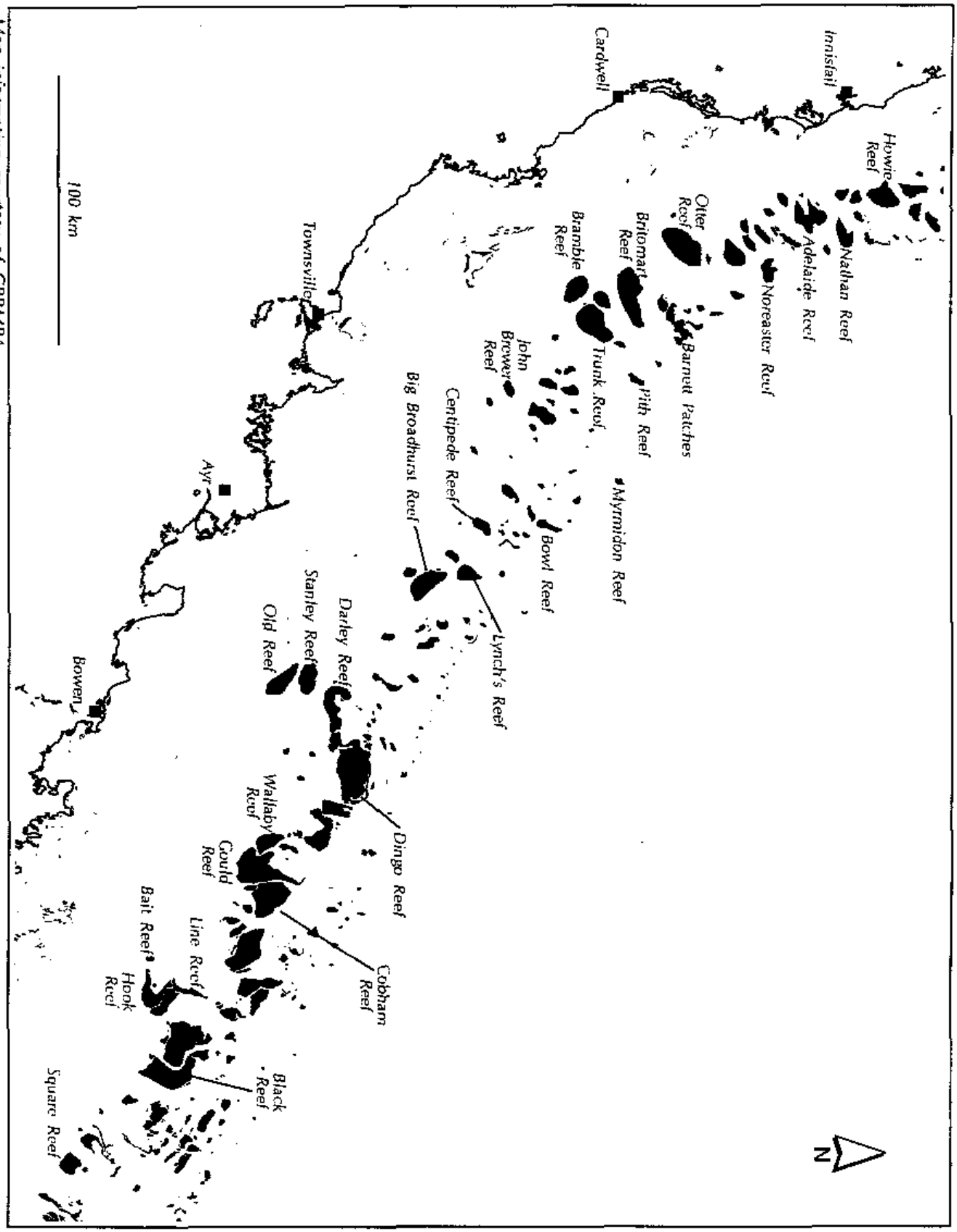
How familiar are you with this reef?
☐ *1st dive* ☐ 2nd dive ☐ 3rd dive
☐ Many dives

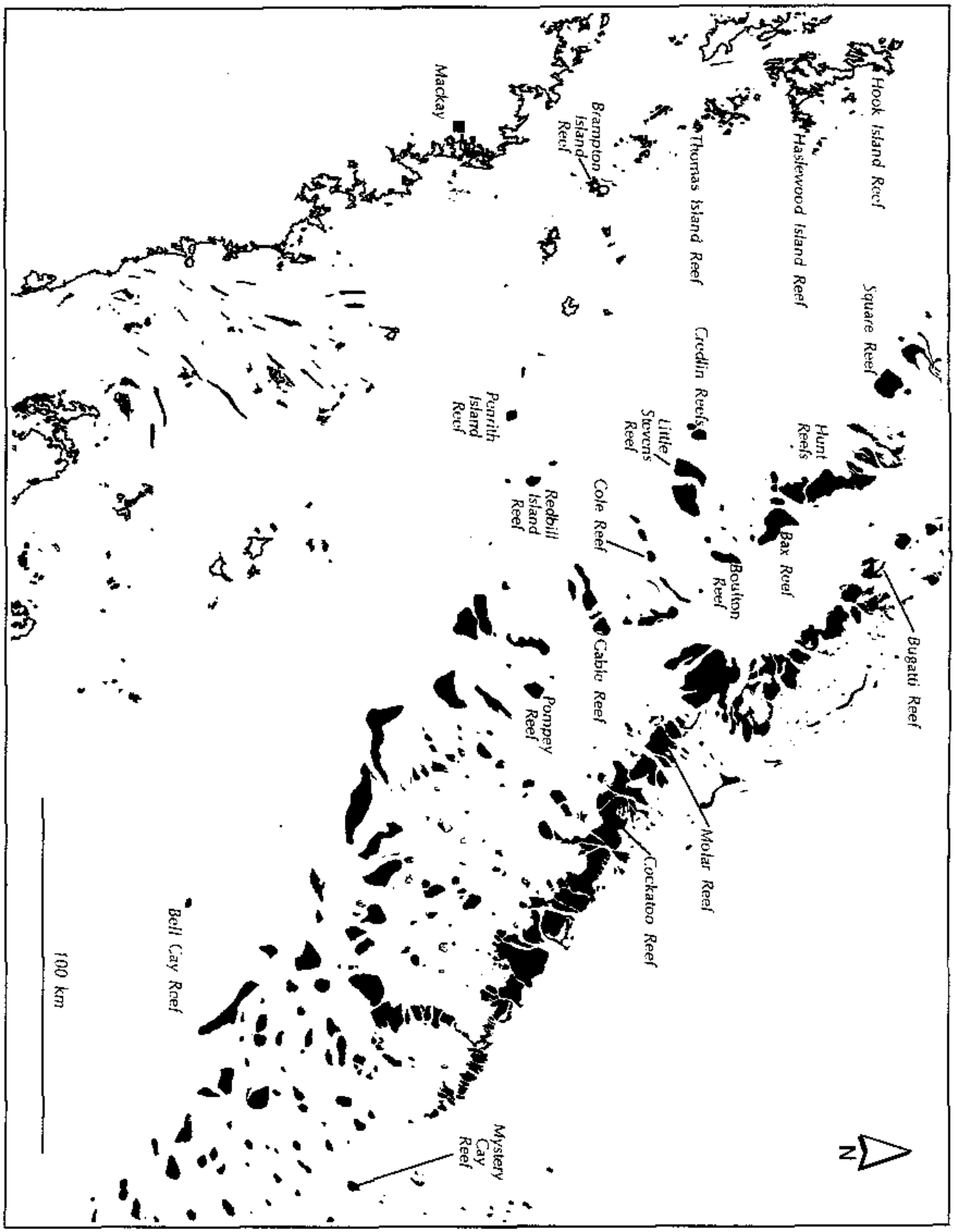
We would appreciate receiving your observations. Simply fold and return this form indicating "what, when, *and* where" or give us a call. Please be sure to *indicate the name of* the reef and area (reef front, flat, backslope) *where you* observed damage. As you know, every reef has some degree of damage at all times. However, we are interested in obvious damage which is widespread on a reef, affecting 100's to 1000's of square meters, *rather than just* the odd patch here and there.

Contact: Marji Puotinen
CRC Reef Research Centre
Townsville, QLD 4811
Phone: 077-81-5565
Email: pmap@cathar.tesag.jcu.edu.au

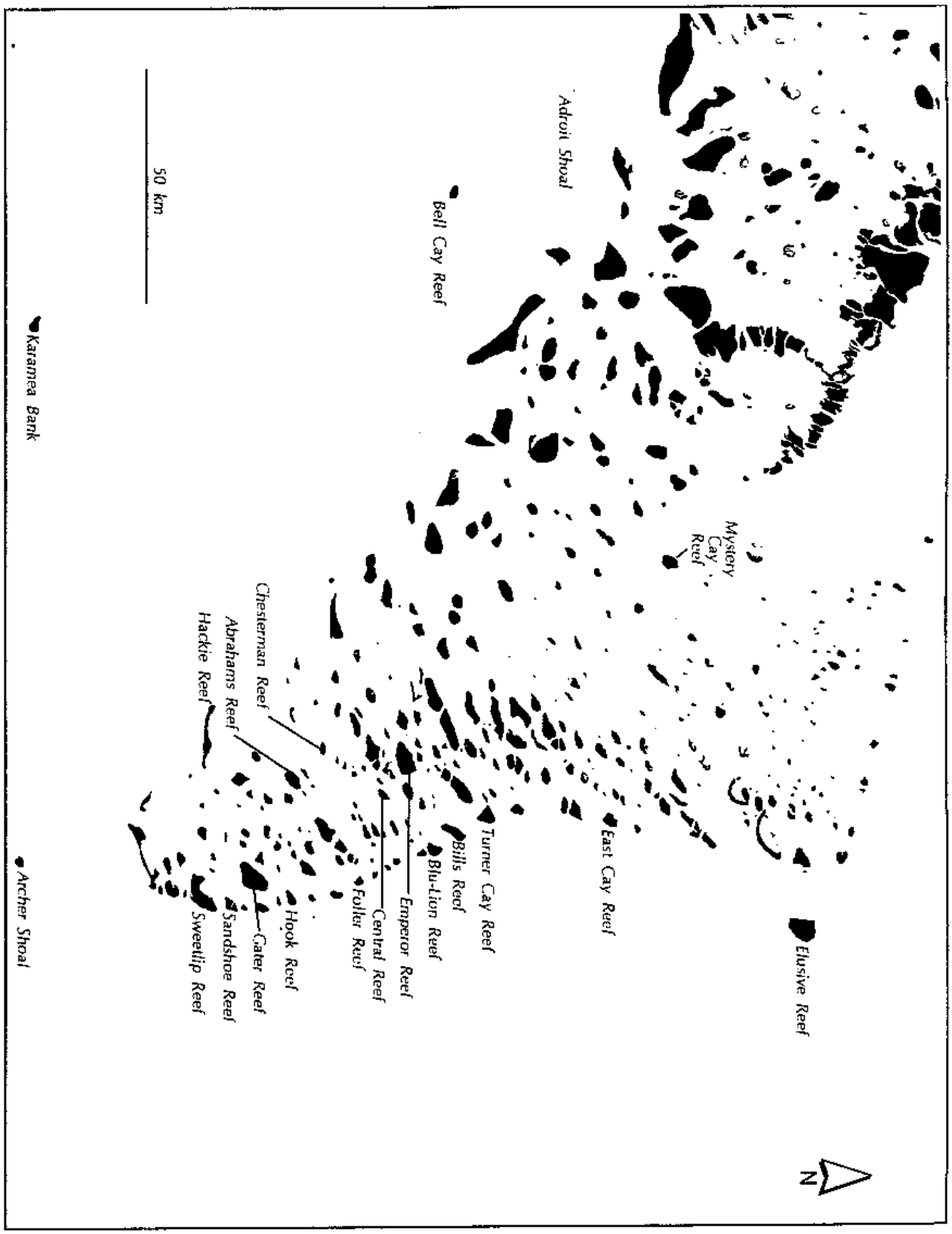



*Map information courtesy of GBRMPA.*

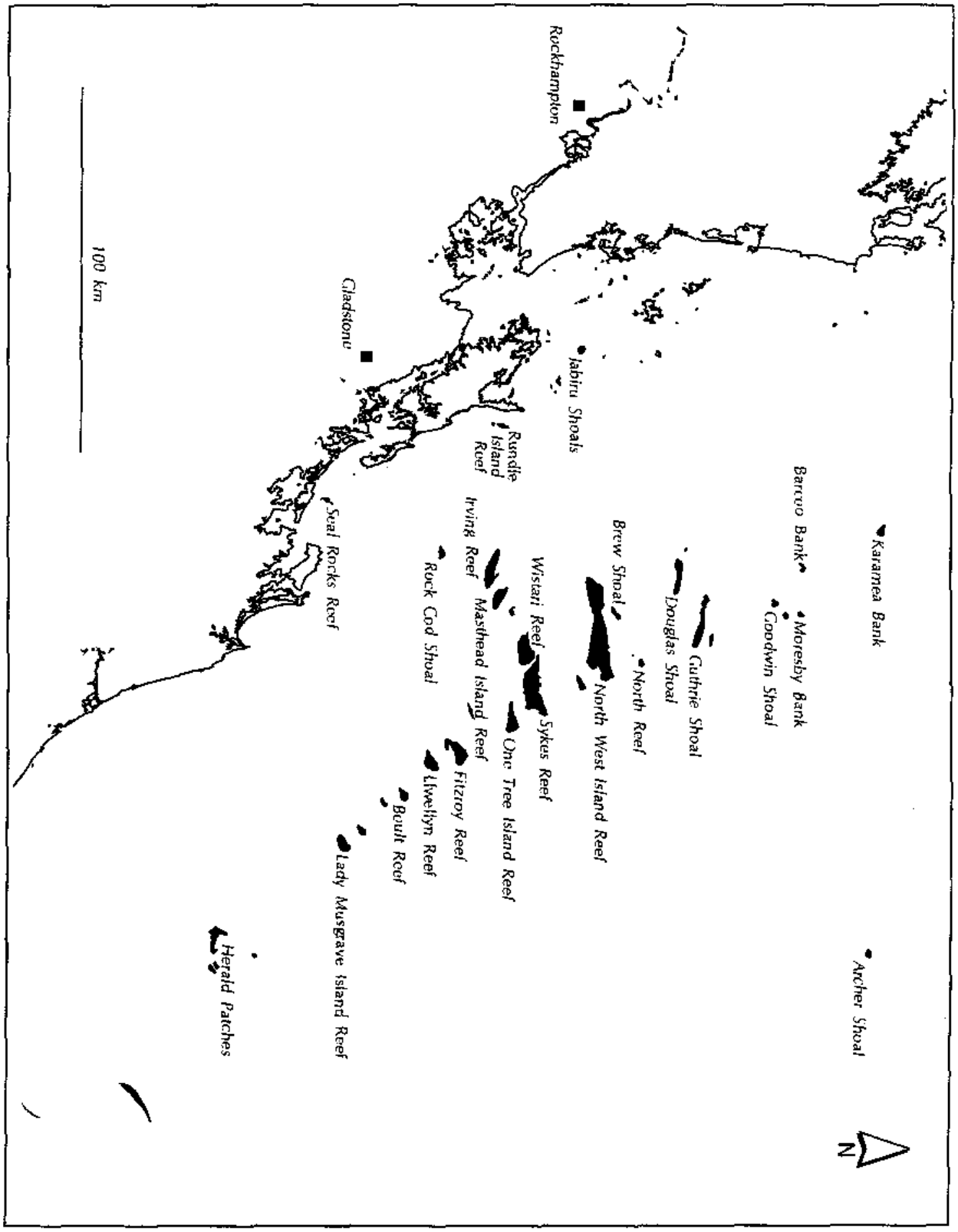

Innisfail
Cardwell
Townsville
Ayr
Bowen
Howick Reef
Nathan Reef
Adelaide Reef
Noreaster Reef
Otter Reef
Britomart Reef
Barnett Patches
Bramble Reef
Trunk Reef
Pith Reef
Myrmidon Reef
John Brewer Reef
Centipede Reef
Big Broadhurst Reef
Bowl Reef
Lynch's Reef
Stanley Reef
Old Reef
Darley Reef
Dingo Reef
Wallaby Reef
Gould Reef
Bait Reef
Line Reef
Hook Reef
Cobham Reef
Black Reef
Square Reef
N
100 km
Map information courtesy of GBRMPA.




Map information courtesy of GBRMPA.




Map information courtesy of GBRMPA.




Map information courtesy of GBRMPA.

# APPENDIX 2: List of AML Scripts

- **Preparing the data**

| | |
|---|---|
| Densify1hr | Interpolate eye positions from variable time intervals to a one-hourly time step |
| Densifystep1 | Subprogram for 1 hour time step |
| Densifystep2 | Subprogram for 2 hour time step |
| Densifystep3 | Subprogram for 3 hour time step |
| Densifystep4 | Subprogram for 4 hour time step |
| Densifystep5 | Subprogram for 5 hour time step |
| Densifystep6 | Subprogram for 6 hour time step |
| Densifystep7 | Subprogram for 7 hour time step |
| Densifystep8 | Subprogram for 8 hour time step |
| Densifystep9 | Subprogram for 9 hour time step |
| Densifystep10 | Subprogram for 10 hour time step |
| Densifystep11 | Subprogram for 11 hour time step |
| Densifystep12 | Subprogram for 12 hour time step |
| Densifystep13 | Subprogram for 13 hour time step |
| Densifystep14 | Subprogram for 14 hour time step |
| Densifystep15 | Subprogram for 15 hour time step |
| Densifystep16 | Subprogram for 16 hour time step |
| Densifystep17 | Subprogram for 17 hour time step |
| Densifystep18 | Subprogram for 18 hour time step |
| Densifystep19 | Subprogram for 19 hour time step |
| Densifystep20 | Subprogram for 20 hour time step |
| Densifystep21 | Subprogram for 21 hour time step |
| Findnearaims | Find the proximity of each AIMS LTM site to the nearest cyclone in a given year from 1910 to 1999. |

- **Hindcasting the cyclone wind field**

| | |
|---|---|
| Tcwind | Main program |
| Setup | Sets key variables |
| Coriolis | Calculates coriolis parameter |
| Setupgrid | Establishes the position of the cyclone eye |
| Distangle | Finds the distance & angle of grid cells from the eye |
| Speed | Calculates 10 metre cyclone wind speeds |
| Dir | Calculates cyclone wind direction |

- **Estimating exposure**

| | |
|---|---|
| Findreefaspect | Identifies the direction to which each part of each reef faces |
| Findvn | Adjusts cyclone wind speed for within-reef shelter |
| Getexposure | Main program |
| Getbyangle | Iterative loop to create fetch lines for each 7.5 degree increment |
| Getsegment | Iterative loop to save the correct fetch line for a given direction |
| Mergelines | Appends fetch lines for all angles into one file for each site |

- **Miscellaneous**

| | |
|---|---|
| Storeobs | Writes wind speed & direction values to a table for each reef site of interest |
| Tcucircles | Map uncertainty of cyclone eye positions for each cyclone |

```
/*DENSIFY1HR.AML
/*AML to densify cyclone eye positions from variable to hourly intervals
/*
/*    Error routine to stop the program immediately with any error
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Set program variables
/*
&sv .count = 1
&sv .newcount = 0
&sv .storm = [name of cyclone]
&sv ext = .pat
&sv .stormcov = %.storm%%ext%
/*
/*    MASTER ITERATIVE DO LOOP
/*
&do &until %.count% = [number of cyclone eye points + 1]
  &sv .count2 = %.count% + 1
/*
/*    Find time step between current and next eye position
/*
  tables
  select %.stormcov%
  &sv time1 = [show RECORD %.count% time]
  &sv time2 = [show RECORD %.count2% time]
  quit
  &select %time2%
   &when 0
    &sv time2 = 24
   &otherwise
    &sv time2 = %time2%
   &end
  &sv .timestep = %time2% - %time1%
  &sv .timestep = [abs %.timestep%]
/*
/*    Creates additional eye positions based on the time step
/*
  &select %.timestep%
   &when 1
     &run densifystep1.aml
   &when 2
     &run densifystep2.aml
   &when 3
     &run densifystep3.aml
   &when 4
     &run densifystep4.aml
   &when 5
     &run densifystep5.aml
   &when 6
     &run densifystep6.aml
   &when 7
     &run densifystep7.aml
   &when 8
     &run densifystep8.aml
   &when 9
```

```
      &run densifystep9.aml
    &when 10
      &run densifystep10.aml
    &when 11
      &run densifystep11.aml
    &when 12
      &run densifystep12.aml
    &when 13
      &run densifystep13.aml
    &when 14
      &run densifystep14.aml
    &when 15
      &run densifystep15.aml
    &when 16
      &run densifystep16.aml
    &when 17
      &run densifystep17.aml
    &when 18
      &run densifystep18.aml
    &otherwise
      &type 'The program is in error'
  &end
/*
/*    Advances the count
/*
  &sv .count = %.count% + 1
&end
/*
/*    END of the LOOP
/*
build 1hrlypts point
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program was killed due to error.
quit
```

```
/*DENSIFYSTEP1.AML
/*  AML to densify between eye positions that are 2 hours apart
/*
&type 'ONE POINT WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   quit
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  END
  quit
/*
/*    Add attributes for the new point(s)
/*
  build 1hrlypts point
  tables
    select 1hrly.tab
    add
    %position1%
    ~
    select hpa.tab
    add
    %hpa1%
    ~
    select vf.tab
    add
    %vf1%
    ~
```

```
    select dir.tab
    add
    %dir%
    ~
    select cat.tab
    add
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP2.AML
/*  AML to densify between storm points that are 3 hours apart
/*
&type 'TWO POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 2
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 2
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 2
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 2
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
```

```
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  END
  quit
  build 1hrlypts point
/*
/*    Add attributes to new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP3.AML
/*  AML to densify between storm points that are 4 hours apart
/*
&type 'THREE POINTS WILL BE ADDED'
tables
select %.stormcov%

/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 3
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 3
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 3
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 3
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
```

```
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  END
  quit
  build 1hrlypts point
/*
/*    Add attributes to new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
```

```
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP4.AML
/*  AML to densify between storm points that are 5 hours apart
/*
&type 'FOUR POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 4
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 4
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 4
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 4
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
```

```
&sv vffour = %vfthree% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  END
  quit
  build 1hrlypts point
/*
/*    Add attributes to new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    ~
    select dir.tab
    add
    %dir%
    %dir%
```

```
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP5.AML
/*  AML to densify between storm points that are 6 hours apart
/*
&type 'FIVE POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 5
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 5
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 5
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 5
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
/*
```

```
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  END
  quit
  build 1hrlypts point
/*
/*    Add attributes to new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    ~
    select vf.tab
```

```
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP6.AML
/*  AML to densify between storm points that are 7 hours apart
/*
&type 'SIX POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 6
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 6
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 6
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 6
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
```

```
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  END
  quit
  build 1hrlypts point
/*
/*    Add attributes to the new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    ~
```

```
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    %vfsix%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP7.AML
/*  AML to densify between storm points that are 8 hours apart
/*
&type 'SEVEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 7
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 7
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 7
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 7
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   quit
/*
```

```
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  END
  quit
  build 1hrlypts point
/*
/*    Add attributes to the new points
/*
  tables
    select 1hrly.tab
```

```
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    %hpaseven%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    %vfsix%
    %vfseven%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP8.AML
/*  AML to densify between storm points that are 9 hours apart
/*
&type 'EIGHT POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 8
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 8
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 8
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 8
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
```

```
   &sv position8 = %pos1% + 7
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
```

```
  END
  quit
  build 1hrlypts point
/*
/*    Add attributes to the new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    %hpaseven%
    %hpaeight%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    %vfsix%
    %vfseven%
    %vfeight%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
```

```
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP9.AML
/*  AML to densify between storm points that are 10 hours apart
/*
&type 'NINE POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 9
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 9
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 9
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 9
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
```

```
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
```

```
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    %hpaseven%
    %hpaeight%
    %hpanine%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    %vfsix%
    %vfseven%
    %vfeight%
    %vfnine%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
```

```
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP10.AML
/*  AML to densify between storm points that are 11 hours apart
/*
&type 'TEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 10
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 10
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 10
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 10
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
```

```
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
```

```
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  END
  quit
/*
/*    Create attributes for new points
/*
  build 1hrlypts point
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    %position10%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    %hpaseven%
    %hpaeight%
    %hpanine%
    %hpaten%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    %vfsix%
    %vfseven%
```

```
    %vfeight%
    %vfnine%
    %vften%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP11.AML
/*  AML to densify between storm points that are 12 hours apart
/*
&type 'ELEVEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 11
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 11
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 11
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 11
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
```

```
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
```

```
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    %position10%
    %position11%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    %hpaseven%
    %hpaeight%
    %hpanine%
    %hpaten%
    %hpaeleven%
```

```
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    %vfsix%
    %vfseven%
    %vfeight%
    %vfnine%
    %vften%
    %vfeleven%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP12.AML
/*  AML to densify between storm points that are 13 hours apart
/*
&type 'TWELVE POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 12
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 12
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 12
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 12
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
/*
/*    Find time labels
```

```
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
/*
/*    Get strings for entry into Generate
```

```
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  %.coord12%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    %position10%
    %position11%
    %position12%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
```

```
%hpathree%
%hpafour%
%hpafive%
%hpasix%
%hpaseven%
%hpaeight%
%hpanine%
%hpaten%
%hpaeleven%
%hpa2%
~
select vf.tab
add
%vf1%
%vftwo%
%vfthree%
%vffour%
%vffive%
%vfsix%
%vfseven%
%vfeight%
%vfnine%
%vften%
%vfeleven%
%vf2%
~
select dir.tab
add
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
~
select cat.tab
add
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
~
select 1hrlypts.pat
&sv .newcount = [show NUMBER TOTAL]
```

```
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP13.AML
/*  AML to densify between storm points that are 14 hours apart
/*
&type 'THIRTEEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 13
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 13
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 13
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 13
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
   &sv ythirteen = %ytwelve% + %addy%
```

```
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
```

```
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = &id13%%comma%%xthirteen%%commoa%%ythirteen%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  %.coord12%
  %.coord13%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
```

```
%position10%
%position11%
%position12%
%position13%
~
select hpa.tab
add
%hpa1%
%hpatwo%
%hpathree%
%hpafour%
%hpafive%
%hpasix%
%hpaseven%
%hpaeight%
%hpanine%
%hpaten%
%hpaeleven%
%hpatwelve%
%hpa2%
~
select vf.tab
add
%vf1%
%vftwo%
%vfthree%
%vffour%
%vffive%
%vfsix%
%vfseven%
%vfeight%
%vfnine%
%vften%
%vfeleven%
%vftwelve%
%vf2%
~
select dir.tab
add
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
~
select cat.tab
add
%cat%
%cat%
%cat%
```

```
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP14.AML
/*  AML to densify between storm points that are 15 hours apart
/*
&type 'FOURTEEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 14
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 14
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 14
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 14
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
   &sv xfourteen = %xthirteen% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
```

```
   &sv ythirteen = %ytwelve% + %addy%
   &sv yfourteen = %ythirteen% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   &sv position14 = %pos1% + 13
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpatwelve% + %addhpa%
&sv hpafourteen = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vftwelve% + %addvf%
&sv vffourteen = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
```

```
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
  &sv id14 = %id13% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = &id13%%comma%%xthirteen%%commoa%%ythirteen%
  &sv .coord14 = %id14%%comma%%xfourteen%%comma%%yfourteen%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  %.coord12%
  %.coord13%
  %.coord14%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
```

```
%position2%
%position3%
%position4%
%position5%
%position6%
%position7%
%position8%
%position9%
%position10%
%position11%
%position12%
%position13%
%position14%
~
select hpa.tab
add
%hpa1%
%hpatwo%
%hpathree%
%hpafour%
%hpafive%
%hpasix%
%hpaseven%
%hpaeight%
%hpanine%
%hpaten%
%hpaeleven%
%hpatwelve%
%hpathirteen%
%hpa2%
~
select vf.tab
add
%vf1%
%vftwo%
%vfthree%
%vffour%
%vffive%
%vfsix%
%vfseven%
%vfeight%
%vfnine%
%vften%
%vfeleven%
%vftwelve%
%vfthirteen%
%vf2%
~
select dir.tab
add
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
```

```
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP15.AML
/*  AML to densify between storm points that are 16 hours apart
/*
&type 'FIFTEEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 15
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 15 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 15
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 15
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
   &sv xfourteen = %xthirteen% + %addx%
   &sv xfifteen = %xfourteen% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
```

```
   &sv ythirteen = %ytwelve% + %addy%
   &sv yfourteen = %ythirteen% + %addy%
   &sv yfifteen = %yfourteen% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   &sv position14 = %pos1% + 13
   &sv position15 = %pos1% + 14
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpatwelve% + %addhpa%
&sv hpafourteen = %hpathirteen% + %addhpa%
&sv hpafifteen = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vftwelve% + %addvf%
&sv vffourteen = %vfthirteen% + %addvf%
&sv vffifteen = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
```

```
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
  &sv id14 = %id13% + 1
  &sv id15 = %id14% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = &id13%%comma%%xthirteen%%commoa%%ythirteen%
  &sv .coord14 = %id14%%comma%%xfourteen%%comma%%yfourteen%
  &sv .coord15 = %id15%%comma%%xfifteen%%comma%%yfifteen%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  %.coord12%
  %.coord13%
  %.coord14%
  %.coord15%
  END
  quit
  build 1hrlypts point
```

```
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    %position10%
    %position11%
    %position12%
    %position13%
    %position14%
    %position15%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    %hpaseven%
    %hpaeight%
    %hpanine%
    %hpaten%
    %hpaeleven%
    %hpatwelve%
    %hpathirteen%
    %hpafourteen%
    %hpa2%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    %vfsix%
    %vfseven%
    %vfeight%
    %vfnine%
    %vften%
    %vfeleven%
    %vftwelve%
    %vfthirteen%
    %vffourteen%
    %vf2%
    ~
```

```
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP16.AML
/*  AML to densify between storm points that are 17 hours apart
/*
&type 'SIXTEEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 16
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 16
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 16
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 16
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
   &sv xfourteen = %xthirteen% + %addx%
   &sv xfifteen = %xfourteen% + %addx%
   &sv xsixteen = %xfifteen% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
```

```
   &sv ytwelve = %yeleven% + %addy%
   &sv ythirteen = %ytwelve% + %addy%
   &sv yfourteen = %ythirteen% + %addy%
   &sv yfifteen = %yfourteen% + %addy%
   &sv ysixteen = %yfifteen% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   &sv position14 = %pos1% + 13
   &sv position15 = %pos1% + 14
   &sv position16 = %pos1% + 15
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpatwelve% + %addhpa%
&sv hpafourteen = %hpathirteen% + %addhpa%
&sv hpafifteen = %hpafourteen% + %addhpa%
&sv hpasixteen = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vftwelve% + %addvf%
&sv vffourteen = %vfthirteen% + %addvf%
```

```
&sv vffifteen = %vffourteen% + %addvf%
&sv vfsixteen = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
  &sv id14 = %id13% + 1
  &sv id15 = %id14% + 1
  &sv id16 = %id15% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = &id13%%comma%%xthirteen%%commoa%%ythirteen%
  &sv .coord14 = %id14%%comma%%xfourteen%%comma%%yfourteen%
  &sv .coord15 = %id15%%comma%%xfifteen%%comma%%yfifteen%
  &sv .coord16 = %id16%%comma%%xsixteen%%comma%%ysixteen%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
```

```
  %.coord12%
  %.coord13%
  %.coord14%
  %.coord15%
  %.coord16%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    %position10%
    %position11%
    %position12%
    %position13%
    %position14%
    %position15%
    %position16%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    %hpaseven%
    %hpaeight%
    %hpanine%
    %hpaten%
    %hpaeleven%
    %hpatwelve%
    %hpathirteen%
    %hpafourteen%
    %hpafifteen%
    %hpa2%
    ~
    select vf.tab
    add
    %vf1%
    %vftwo%
    %vfthree%
    %vffour%
    %vffive%
    %vfsix%
```

```
    %vfseven%
    %vfeight%
    %vfnine%
    %vften%
    %vfeleven%
    %vftwelve%
    %vfthirteen%
    %vffourteen%
    %vffifteen%
    %vf2%
    ~
    select dir.tab
    add
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP17.AML
/*  AML to densify between storm points that are 18 hours apart
/*
&type 'SEVENTEEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 17
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 17
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 17
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 17
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
   &sv xfourteen = %xthirteen% + %addx%
   &sv xfifteen = %xfourteen% + %addx%
   &sv xsixteen = %xfifteen% + %addx%
   &sv xseventeen = %xsixteen% + %addx%
/*
/*    Find y coordinates/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
```

```
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
   &sv ythirteen = %ytwelve% + %addy%
   &sv yfourteen = %ythirteen% + %addy%
   &sv yfifteen = %yfourteen% + %addy%
   &sv ysixteen = %yfifteen% + %addy%
   &sv yseventeen = %ysixteen% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   &sv position14 = %pos1% + 13
   &sv position15 = %pos1% + 14
   &sv position16 = %pos1% + 15
   &sv position17 = %pos1% + 16
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpatwelve% + %addhpa%
&sv hpafourteen = %hpathirteen% + %addhpa%
&sv hpafifteen = %hpafourteen% + %addhpa%
&sv hpasixteen = %hpafifteen% + %addhpa%
&sv hpaseventeen = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
```

```
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vftwelve% + %addvf%
&sv vffourteen = %vfthirteen% + %addvf%
&sv vffifteen = %vffourteen% + %addvf%
&sv vfsixteen = %vffifteen% + %addvf%
&sv vfseventeen = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
  &sv id14 = %id13% + 1
  &sv id15 = %id14% + 1
  &sv id16 = %id15% + 1
  &sv id17 = %id16% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = &id13%%comma%%xthirteen%%commoa%%ythirteen%
  &sv .coord14 = %id14%%comma%%xfourteen%%comma%%yfourteen%
  &sv .coord15 = %id15%%comma%%xfifteen%%comma%%yfifteen%
  &sv .coord16 = %id16%%comma%%xsixteen%%comma%%ysixteen%
  &sv .coord17 = %id17%%comma%%xseventeen%%comma%%yseventeen%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
```

```
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  %.coord12%
  %.coord13%
  %.coord14%
  %.coord15%
  %.coord16%
  %.coord17%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    %position10%
    %position11%
    %position12%
    %position13%
    %position14%
    %position15%
    %position16%
    %position17%
    ~
    select hpa.tab
    add
    %hpa1%
    %hpatwo%
    %hpathree%
    %hpafour%
    %hpafive%
    %hpasix%
    %hpaseven%
    %hpaeight%
    %hpanine%
    %hpaten%
    %hpaeleven%
    %hpatwelve%
    %hpathirteen%
    %hpafourteen%
    %hpafifteen%
    %hpasixteen%
```

```
%hpa2%
~
select vf.tab
add
%vf1%
%vftwo%
%vfthree%
%vffour%
%vffive%
%vfsix%
%vfseven%
%vfeight%
%vfnine%
%vften%
%vfeleven%
%vftwelve%
%vfthirteen%
%vffourteen%
%vffifteen%
%vfsixteen%
%vf2%
~
select dir.tab
add
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
~
select cat.tab
add
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
```

```
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP18.AML
/*  AML to densify between storm points that are 19 hours apart
/*
&type 'EIGHTEEN POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 18
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 18
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 18
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 18
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
   &sv xfourteen = %xthirteen% + %addx%
   &sv xfifteen = %xfourteen% + %addx%
   &sv xsixteen = %xfifteen% + %addx%
   &sv xseventeen = %xsixteen% + %addx%
   &sv xeighteen = %xseventeen% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
```

```
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
   &sv ythirteen = %ytwelve% + %addy%
   &sv yfourteen = %ythirteen% + %addy%
   &sv yfifteen = %yfourteen% + %addy%
   &sv ysixteen = %yfifteen% + %addy%
   &sv yseventeen = %ysixteen% + %addy%
   &sv yeighteen = %yseventeen% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   &sv position14 = %pos1% + 13
   &sv position15 = %pos1% + 14
   &sv position16 = %pos1% + 15
   &sv position17 = %pos1% + 16
   &sv position18 = %pos1% + 17
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpatwelve% + %addhpa%
&sv hpafourteen = %hpathirteen% + %addhpa%
&sv hpafifteen = %hpafourteen% + %addhpa%
&sv hpasixteen = %hpafifteen% + %addhpa%
&sv hpaseventeen = %hpasixteen% + %addhpa%
&sv hpaeighteen = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
```

```
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vftwelve% + %addvf%
&sv vffourteen = %vfthirteen% + %addvf%
&sv vffifteen = %vffourteen% + %addvf%
&sv vfsixteen = %vffifteen% + %addvf%
&sv vfseventeen = %vfsixteen% + %addvf%
&sv vfeighteen = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
  &sv id14 = %id13% + 1
  &sv id15 = %id14% + 1
  &sv id16 = %id15% + 1
  &sv id17 = %id16% + 1
  &sv id18 = %id17% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = %id13%%comma%%xthirteen%%comma%%ythirteen%
  &sv .coord14 = %id14%%comma%%xfourteen%%comma%%yfourteen%
  &sv .coord15 = %id15%%comma%%xfifteen%%comma%%yfifteen%
  &sv .coord16 = %id16%%comma%%xsixteen%%comma%%ysixteen%
  &sv .coord17 = %id17%%comma%%xseventeen%%comma%%yseventeen%
  &sv .coord18 = %id18%%comma%%xeighteen%%comma%%yeighteen%
/*
/*    Add new points to the coverage
/*
```

```
generate 1hrlypts
copytics %.storm%
point
%.coord1%
%.coord2%
%.coord3%
%.coord4%
%.coord5%
%.coord6%
%.coord7%
%.coord8%
%.coord9%  %.coord10%
%.coord11%
%.coord12%
%.coord13%
%.coord14%
%.coord15%
%.coord16%
%.coord17%
%.coord18%
END
quit
build 1hrlypts point
tables
  select 1hrly.tab
  add
  %position1%
  %position2%
  %position3%
  %position4%
  %position5%
  %position6%
  %position7%
  %position8%
  %position9%
  %position10%
  %position11%
  %position12%
  %position13%
  %position14%
  %position15%
  %position16%
  %position17%
  %position18%
  ~
  select hpa.tab
  add
  %hpa1%
  %hpatwo%
  %hpathree%
  %hpafour%
  %hpafive%
  %hpasix%
  %hpaseven%
  %hpaeight%
  %hpanine%
  %hpaten%
  %hpaeleven%
```

```
%hpatwelve%
%hpathirteen%
%hpafourteen%
%hpafifteen%
%hpasixteen%
%hpaseventeen%
%hpa2%
~
select vf.tab
add
%vf1%
%vftwo%    %vfthree%
%vffour%
%vffive%
%vfsix%    %vfseven%
%vfeight%
%vfnine%
%vften%
%vfeleven%
%vftwelve%
%vfthirteen%
%vffourteen%
%vffifteen%
%vfsixteen%
%vfseventeen%
%vf2%
~
select dir.tab
add
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
~
select cat.tab
add
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
%cat%
```

```
    %cat%
    %cat%
    %cat%
    %cat%    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP19.AML
/*  AML to densify between storm points that are 20 hours apart
/*
&type 'NINETEEN POINTS WILL BE ADDED'
tablesselect %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 19
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 19
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 19
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 19
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
   &sv xfourteen = %xthirteen% + %addx%
   &sv xfifteen = %xfourteen% + %addx%
   &sv xsixteen = %xfifteen% + %addx%
   &sv xseventeen = %xsixteen% + %addx%
   &sv xeighteen = %xseventeen% + %addx%
   &sv xnineteen = %xeighteen% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
```

```
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
   &sv ythirteen = %ytwelve% + %addy%
   &sv yfourteen = %ythirteen% + %addy%
   &sv yfifteen = %yfourteen% + %addy%
   &sv ysixteen = %yfifteen% + %addy%
   &sv yseventeen = %ysixteen% + %addy%
   &sv yeighteen = %yseventeen% + %addy%
   &sv ynineteen = %yeighteen% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   &sv position14 = %pos1% + 13
   &sv position15 = %pos1% + 14
   &sv position16 = %pos1% + 15
   &sv position17 = %pos1% + 16
   &sv position18 = %pos1% + 17
   &sv position19 = %pos1% + 18
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpatwelve% + %addhpa%
&sv hpafourteen = %hpathirteen% + %addhpa%
&sv hpafifteen = %hpafourteen% + %addhpa%
&sv hpasixteen = %hpafifteen% + %addhpa%
&sv hpaseventeen = %hpasixteen% + %addhpa%
&sv hpaeighteen = %hpaseventeen% +%addhpa%
&sv hpanineteen = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
```

```
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vftwelve% + %addvf%
&sv vffourteen = %vfthirteen% + %addvf%
&sv vffifteen = %vffourteen% + %addvf%
&sv vfsixteen = %vffifteen% + %addvf%
&sv vfseventeen = %vfsixteen% + %addvf%
&sv vfeighteen = %vfseventeen% + %addvf%
&sv vfnineteen = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
  &sv id14 = %id13% + 1
  &sv id15 = %id14% + 1
  &sv id16 = %id15% + 1
  &sv id17 = %id16% + 1
  &sv id18 = %id17% + 1
  &sv id19 = %id18% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = &id13%%comma%%xthirteen%%commoa%%ythirteen%
  &sv .coord14 = %id14%%comma%%xfourteen%%comma%%yfourteen%
  &sv .coord15 = %id15%%comma%%xfifteen%%comma%%yfifteen%
```

```
  &sv .coord16 = %id16%%comma%%xsixteen%%comma%%ysixteen%
  &sv .coord17 = %id17%%comma%%xseventeen%%comma%%yseventeen%
  &sv .coord18 = %id18%%comma%%xeighteen%%comma%%yeighteen%
  &sv .coord19 = %id19%%comma%%xnineteen%%comma%%ynineteen%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  %.coord12%
  %.coord13%
  %.coord14%
  %.coord15%
  %.coord16%
  %.coord17%
  %.coord18%
  %.coord19%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    %position10%
    %position11%
    %position12%
    %position13%
    %position14%
    %position15%
    %position16%
    %position17%
    %position18%
    %position19%
    ~
```

```
select hpa.tab
add
%hpa1%
%hpatwo%
%hpathree%
%hpafour%
%hpafive%
%hpasix%
%hpaseven%
%hpaeight%
%hpanine%
%hpaten%
%hpaeleven%
%hpatwelve%
%hpathirteen%
%hpafourteen%
%hpafifteen%
%hpasixteen%
%hpaseventeen%
%hpaeighteen%
%hpa2%
~
select vf.tab
add
%vf1%
%vftwo%
%vfthree%
%vffour%
%vffive%
%vfsix%
%vfseven%
%vfeight%
%vfnine%
%vften%
%vfeleven%
%vftwelve%
%vfthirteen%
%vffourteen%
%vffifteen%
%vfsixteen%
%vfseventeen%
%vfeighteen%
%vf2%
~
select dir.tab
add
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
%dir%
```

```
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP20.AML
/*  AML to densify between storm points that are 21 hours apart
/*
&type 'TWENTY POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 20
 &sv deltay = %y2% - %y1%
 &sv addy = %deltay% / 20
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 20
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 20
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
   &sv xfourteen = %xthirteen% + %addx%
   &sv xfifteen = %xfourteen% + %addx%
   &sv xsixteen = %xfifteen% + %addx%
   &sv xseventeen = %xsixteen% + %addx%
   &sv xeighteen = %xseventeen% + %addx%
   &sv xnineteen = %xeighteen% + %addx%
   &sv xtwenty = %xnineteen% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
```

```
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
   &sv ythirteen = %ytwelve% + %addy%
   &sv yfourteen = %ythirteen% + %addy%
   &sv yfifteen = %yfourteen% + %addy%
   &sv ysixteen = %yfifteen% + %addy%
   &sv yseventeen = %ysixteen% + %addy%
   &sv yeighteen = %yseventeen% + %addy%
   &sv ynineteen = %yeighteen% + %addy%
   &sv ytwenty = %ynineteen% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   &sv position14 = %pos1% + 13
   &sv position15 = %pos1% + 14
   &sv position16 = %pos1% + 15
   &sv position17 = %pos1% + 16
   &sv position18 = %pos1% + 17
   &sv position19 = %pos1% + 18
   &sv position20 = %pos1% + 19
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%
&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpatwelve% + %addhpa%
&sv hpafourteen = %hpathirteen% + %addhpa%
&sv hpafifteen = %hpafourteen% + %addhpa%
&sv hpasixteen = %hpafifteen% + %addhpa%
&sv hpaseventeen = %hpasixteen% + %addhpa%
&sv hpaeighteen = %hpaseventeen% +%addhpa%
&sv hpanineteen = %hpaeighteen% + %addhpa%
```

```
&sv hpatwenty = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vftwelve% + %addvf%
&sv vffourteen = %vfthirteen% + %addvf%
&sv vffifteen = %vffourteen% + %addvf%
&sv vfsixteen = %vffifteen% + %addvf%
&sv vfseventeen = %vfsixteen% + %addvf%
&sv vfeighteen = %vfseventeen% + %addvf%
&sv vfnineteen = %vfeighteen% + %addvf%
&sv vftwenty = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
  &sv id14 = %id13% + 1
  &sv id15 = %id14% + 1
  &sv id16 = %id15% + 1
  &sv id17 = %id16% + 1
  &sv id18 = %id17% + 1
  &sv id19 = %id18% + 1
  &sv id20 = %id20% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
```

```
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = &id13%%comma%%xthirteen%%commoa%%ythirteen%
  &sv .coord14 = %id14%%comma%%xfourteen%%comma%%yfourteen%
  &sv .coord15 = %id15%%comma%%xfifteen%%comma%%yfifteen%
  &sv .coord16 = %id16%%comma%%xsixteen%%comma%%ysixteen%
  &sv .coord17 = %id17%%comma%%xseventeen%%comma%%yseventeen%
  &sv .coord18 = %id18%%comma%%xeighteen%%comma%%yeighteen%
  &sv .coord19 = %id19%%comma%%xnineteen%%comma%%ynineteen%
  &sv .coord20 = %id20%%comma%%xtwenty%%comma%%ytwenty%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  %.coord12%
  %.coord13%
  %.coord14%
  %.coord15%
  %.coord16%
  %.coord17%
  %.coord18%
  %.coord19%
  %.coord20%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
    %position6%
    %position7%
    %position8%
    %position9%
    %position10%
    %position11%
```

```
%position12%
%position13%
%position14%
%position15%
%position16%
%position17%
%position18%
%position19%
%position20%
~
select hpa.tab
add
%hpa1%
%hpatwo%
%hpathree%
%hpafour%
%hpafive%
%hpasix%
%hpaseven%
%hpaeight%
%hpanine%
%hpaten%
%hpaeleven%
%hpatwelve%
%hpathirteen%
%hpafourteen%
%hpafifteen%
%hpasixteen%
%hpaseventeen%
%hpaeighteen%
%hpanineteen%
%hpa2%
~
select vf.tab
add
%vf1%
%vftwo%
%vfthree%
%vffour%
%vffive%
%vfsix%
%vfseven%
%vfeight%
%vfnine%
%vften%
%vfeleven%
%vftwelve%
%vfthirteen%
%vffourteen%
%vffifteen%
%vfsixteen%
%vfseventeen%
%vfeighteen%
%vfnineteen%
%vf2%
~
select dir.tab
add
```

```
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    %dir%
    ~
    select cat.tab
    add
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    %cat%
    ~
    select 1hrlypts.pat
    &sv .newcount = [show NUMBER TOTAL]
  quit
  &lv .newcount
&return
```

```
/*DENSIFYSTEP21.AML
/*  AML to densify between storm points that are 22 hours apart
/*
&type 'TWENTY ONE POINTS WILL BE ADDED'
tables
select %.stormcov%
/*
/*    Find x,y step
/*
 &sv x1 = [show RECORD %.count% x-coord]
 &sv x2 = [show RECORD %.count2% x-coord]
 &sv y1 = [show RECORD %.count% y-coord]
 &sv y2 = [show RECORD %.count2% y-coord]
 &sv pos1 = [show RECORD %.count% time]
 &sv hpa1 = [show RECORD %.count% hpa]
 &sv hpa2 = [show RECORD %.count2% hpa]
 &sv vf1 = [show RECORD %.count% speed]
 &sv vf2 = [show RECORD %.count2% speed]
 &sv dir = [show RECORD %.count% direction]
 &sv cat = [show RECORD %.count% category]
 &sv deltax = %x2% - %x1%
 &sv addx = %deltax% / 21
 &sv deltay = %y2% - %y1% &sv addy = %deltay% / 21
 &sv deltahpa = %hpa2% - %hpa1%
 &sv addhpa = %deltahpa% / 21
 &sv deltavf = %vf2% - %vf1%
 &sv addvf = %deltavf% / 21
/*
/*    Find x coordinates
/*
   &sv xtwo = %x1% + %addx%
   &sv xthree = %xtwo% + %addx%
   &sv xfour = %xthree% + %addx%
   &sv xfive = %xfour% + %addx%
   &sv xsix = %xfive% + %addx%
   &sv xseven = %xsix% + %addx%
   &sv xeight = %xseven% + %addx%
   &sv xnine = %xeight% + %addx%
   &sv xten = %xnine% + %addx%
   &sv xeleven = %xten% + %addx%
   &sv xtwelve = %xeleven% + %addx%
   &sv xthirteen = %xtwelve% + %addx%
   &sv xfourteen = %xthirteen% + %addx%
   &sv xfifteen = %xfourteen% + %addx%
   &sv xsixteen = %xfifteen% + %addx%
   &sv xseventeen = %xsixteen% + %addx%
   &sv xeighteen = %xseventeen% + %addx%
   &sv xnineteen = %xeighteen% + %addx%
   &sv xtwenty = %xnineteen% + %addx%
   &sv xtwentyone = %xtwenty% + %addx%
/*
/*    Find y coordinates
/*
   &sv ytwo = %y1% + %addy%
   &sv ythree = %ytwo% + %addy%
   &sv yfour = %ythree% + %addy%
   &sv yfive = %yfour% + %addy%
   &sv ysix = %yfive% + %addy%
```

```
   &sv yseven = %ysix% + %addy%
   &sv yeight = %yseven% + %addy%
   &sv ynine = %yeight% + %addy%
   &sv yten = %ynine% + %addy%
   &sv yeleven = %yten% + %addy%
   &sv ytwelve = %yeleven% + %addy%
   &sv ythirteen = %ytwelve% + %addy%
   &sv yfourteen = %ythirteen% + %addy%
   &sv yfifteen = %yfourteen% + %addy%
   &sv ysixteen = %yfifteen% + %addy%
   &sv yseventeen = %ysixteen% + %addy%
   &sv yeighteen = %yseventeen% + %addy%
   &sv ynineteen = %yeighteen% + %addy%
   &sv ytwenty = %ynineteen% + %addy%
   &sv ytwentyone = %ytwenty% + %addy%
/*
/*    Find time labels
/*
   &sv position1 = %pos1%
   &sv position2 = %pos1% + 1
   &sv position3 = %pos1% + 2
   &sv position4 = %pos1% + 3
   &sv position5 = %pos1% + 4
   &sv position6 = %pos1% + 5
   &sv position7 = %pos1% + 6
   &sv position8 = %pos1% + 7
   &sv position9 = %pos1% + 8
   &sv position10 = %pos1% + 9
   &sv position11 = %pos1% + 10
   &sv position12 = %pos1% + 11
   &sv position13 = %pos1% + 12
   &sv position14 = %pos1% + 13
   &sv position15 = %pos1% + 14
   &sv position16 = %pos1% + 15
   &sv position17 = %pos1% + 16
   &sv position18 = %pos1% + 17
   &sv position19 = %pos1% + 18
   &sv position20 = %pos1% + 19
   &sv position21 = %pos1% + 20
   quit
/*
/*    Find hpa labels
&sv hpatwo = %hpa1% + %addhpa%
&sv hpathree = %hpatwo% + %addhpa%
&sv hpafour = %hpathree% + %addhpa%
&sv hpafive = %hpafour% + %addhpa%&sv hpasix = %hpafive% + %addhpa%
&sv hpaseven = %hpasix% + %addhpa%
&sv hpaeight = %hpaseven% + %addhpa%
&sv hpanine = %hpaeight% + %addhpa%
&sv hpaten = %hpanine% + %addhpa%
&sv hpaeleven = %hpaten% + %addhpa%
&sv hpatwelve = %hpaeleven% + %addhpa%
&sv hpathirteen = %hpatwelve% + %addhpa%
&sv hpafourteen = %hpathirteen% + %addhpa%
&sv hpafifteen = %hpafourteen% + %addhpa%
&sv hpasixteen = %hpafifteen% + %addhpa%
&sv hpaseventeen = %hpasixteen% + %addhpa%
&sv hpaeighteen = %hpaseventeen% +%addhpa%
```

```
&sv hpanineteen = %hpaeighteen% + %addhpa%
&sv hpatwenty = %hpanineteen% + %addhpa%
&sv hpatwentyone = %hpa2%
/*
/*    Find speed labels
/*
&sv vftwo = %vf1% + %addvf%
&sv vfthree = %vftwo% + %addvf%
&sv vffour = %vfthree% + %addvf%
&sv vffive = %vffour% + %addvf%
&sv vfsix = %vffive% + %addvf%
&sv vfseven = %vfsix% + %addvf%
&sv vfeight = %vfseven% + %addvf%
&sv vfnine = %vfeight% + %addvf%
&sv vften = %vfnine% + %addvf%
&sv vfeleven = %vften% + %addvf%
&sv vftwelve = %vfeleven% + %addvf%
&sv vfthirteen = %vftwelve% + %addvf%
&sv vffourteen = %vfthirteen% + %addvf%
&sv vffifteen = %vffourteen% + %addvf%
&sv vfsixteen = %vffifteen% + %addvf%
&sv vfseventeen = %vfsixteen% + %addvf%
&sv vfeighteen = %vfseventeen% + %addvf%
&sv vfnineteen = %vfeighteen% + %addvf%
&sv vftwenty = %vfnineteen% + %addvf%
&sv vftwentyone = %vf2%
/*
/*    Find ID numbers for new points to be added to the coverage
/*
  &sv id1 = %.count% + %.newcount%
  &sv id2 = %id1% + 1
  &sv id3 = %id2% + 1
  &sv id4 = %id3% + 1
  &sv id5 = %id4% + 1
  &sv id6 = %id5% + 1
  &sv id7 = %id6% + 1
  &sv id8 = %id7% + 1
  &sv id9 = %id8% + 1
  &sv id10 = %id9% + 1
  &sv id11 = %id10% + 1
  &sv id12 = %id11% + 1
  &sv id13 = %id12% + 1
  &sv id14 = %id13% + 1
  &sv id15 = %id14% + 1
  &sv id16 = %id15% + 1
  &sv id17 = %id16% + 1
  &sv id18 = %id17% + 1
  &sv id19 = %id18% + 1
  &sv id20 = %id20% + 1
  &sv id21 = %id21% + 1
/*
/*    Get strings for entry into Generate
/*
  &sv comma = ,
  &sv .coord1 = %id1%%comma%%x1%%comma%%y1%
  &sv .coord2 = %id2%%comma%%xtwo%%comma%%ytwo%
  &sv .coord3 = %id3%%comma%%xthree%%comma%%ythree%
  &sv .coord4 = %id4%%comma%%xfour%%comma%%yfour%
```

```
  &sv .coord5 = %id5%%comma%%xfive%%comma%%yfive%
  &sv .coord6 = %id6%%comma%%xsix%%comma%%ysix%
  &sv .coord7 = %id7%%comma%%xseven%%comma%%yseven%
  &sv .coord8 = %id8%%comma%%xeight%%comma%%yeight%
  &sv .coord9 = %id9%%comma%%xnine%%comma%%ynine%
  &sv .coord10 = %id10%%comma%%xten%%comma%%yten%
  &sv .coord11 = %id11%%comma%%xeleven%%comma%%yeleven%
  &sv .coord12 = %id12%%comma%%xtwelve%%comma%%ytwelve%
  &sv .coord13 = &id13%%comma%%xthirteen%%commoa%%ythirteen%
  &sv .coord14 = %id14%%comma%%xfourteen%%comma%%yfourteen%
  &sv .coord15 = %id15%%comma%%xfifteen%%comma%%yfifteen%
  &sv .coord16 = %id16%%comma%%xsixteen%%comma%%ysixteen%
  &sv .coord17 = %id17%%comma%%xseventeen%%comma%%yseventeen%
  &sv .coord18 = %id18%%comma%%xeighteen%%comma%%yeighteen%
  &sv .coord19 = %id19%%comma%%xnineteen%%comma%%ynineteen%
  &sv .coord20 = %id20%%comma%%xtwenty%%comma%%ytwenty%
  &sv .coord21 = %id21%%comma%%xtwentyone%%comma%%ytwentyone%
/*
/*    Add new points to the coverage
/*
  generate 1hrlypts
  copytics %.storm%
  point
  %.coord1%
  %.coord2%
  %.coord3%
  %.coord4%
  %.coord5%
  %.coord6%
  %.coord7%
  %.coord8%
  %.coord9%
  %.coord10%
  %.coord11%
  %.coord12%
  %.coord13%
  %.coord14%
  %.coord15%
  %.coord16%
  %.coord17%
  %.coord18%
  %.coord19%
  %.coord20%
  %.coord21%
  END
  quit
  build 1hrlypts point
/*
/*    Create attributes for new points
/*
  tables
    select 1hrly.tab
    add
    %position1%
    %position2%
    %position3%
    %position4%
    %position5%
```

```
%position6%
%position7%
%position8%
%position9%
%position10%
%position11%
%position12%
%position13%
%position14%
%position15%
%position16%
%position17%
%position18%
%position19%
%position20%
%position21%
~
select hpa.tab
add
%hpa1%
%hpatwo%
%hpathree%
%hpafour%
%hpafive%
%hpasix%
%hpaseven%
%hpaeight%
%hpanine%
%hpaten%
%hpaeleven%
%hpatwelve%
%hpathirteen%
%hpafourteen%
%hpafifteen%
%hpasixteen%
%hpaseventeen%
%hpaeighteen%
%hpanineteen%
%hpatwenty%
%hpa2%
~
select vf.tab
add
%vf1%
%vftwo%
%vfthree%
%vffour%
%vffive%
%vfsix%
%vfseven%
%vfeight%
%vfnine%
%vften%
%vfeleven%
%vftwelve%
%vfthirteen%
%vffourteen%
%vffifteen%
```

```
  %vfsixteen%
  %vfseventeen%
  %vfeighteen%
  %vfnineteen%
  %vftwenty%
  %vf2%
  ~
  select dir.tab
  add
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  %dir%
  ~
  select cat.tab
  add
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  %cat%
  ~
  select 1hrlypts.pat
  &sv .newcount = [show NUMBER TOTAL]
quit
```

```
  &lv .newcount
&return
```

```
/*FINDNEARAIMS.AML
/*    AML to find the distance of each reef monitored by AIMS from each of
/*    cyclones recorded for Queensland from 1910 to 1999.
/*
/*    Before I ran this AML, I built the cyclone tracks using the previous
/*    AML.  I also manually entered the AIMS LTM reef positions in ArcView
/*    to create the coverage 'ltmpts' based on LTM status reports.
/*
&sv count = 1
/*
/*    Set variables
/*
&sv near = track
&sv out = dist
/*
/*    Iterative loop to examine one cyclone at a time
/*
&do &until %count% = 335 [number of cyclones + 1]
/*
/*          Set variables that vary with the count
/*
  &sv incov = %in%
  &sv nearcov = %near%%count%
  &sv outcov = %out%%count%
/*
/*          Finds the distance from each LTM site to the nearest section
/*          of the current cyclone track
/*
  near ltmpts %nearcov% line 500000000 %outcov% location
/*
/*          Advances the count
/*
  &sv count = %count% + 1
&end
/*
/*    End of iterative loop
/*
quit
```

```
/*TCWIND.AML
/*
/*AML to hindcast cyclone surface wind speeds from basic meteorological
/*observations.  Equations adapted from McConochie et al "A Coral Sea
/*Wind Model Intended for Wave Modelling", Coast and Ports '99, April
/*1999, Perth, pp. 413-418.  This version is the raster implementation
/* (hindcasts for the entire area at once).
/*
/*    Error routine to stop the program immediately with any error
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Start iterative loop to complete one eye position at a time
/*
&sv .count = 1
&do &until %.count% = [number of eye positions + 1]
  &run setup.aml
  &run coriolis.aml
  &run setupgrid.aml
  &run distangle.aml
  &run speed.aml
  &run dir.aml
  kill (! %.outgrid% %.anglegrid% theta anglesite !) all
  &sv .count = %.count% + 1
&end
/*
/*    End of loop
/*
&type The program is complete
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program is in error.
quit
```

```
/*SETUP.AML
/*    AML to read variables needed for hindcasting from cyclone database
files
/*
/*    Sets up error program
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Reads basic cyclone parameters from eye point file
/*
tables
  select 1hrlypts.pat
  &sv .hpa = [show RECORD %.count% hpa]
  &sv .vf = [show RECORD %.count% vf]
  &sv .direction = [show RECORD %.count% direction]
  &sv .latitude = [show RECORD %.count% latitude]
quit
&sv .e = 2.718281828459045
/*
/*    ambient air pressure in m per meters cubed
/*
&sv .Pa = .0115
/*
/*    SET THESE BY HAND FOR EACH INDIVIDUAL CYCLONE
/*
/*    Radius of maximum winds (at eye, secondary maxima)
/*
&sv .R = 30000
&sv .R2 = 200000
/*
/*    Choose ambient pressures from means at Willis Island by month
/*
/*&sv .ambientP = 1008.5
      /*January
/*&sv .ambientP = 1008.0
      /*February
&sv .ambientP = 1009.9
      /*March
/*&sv .ambientP = 1012.3
      /*April
/*&sv .ambientP = 1014.0
      /*May
/*&sv .ambientP = 1009.9
      /*December
/*&sv .ambientP = 1008
      /*Other known
/*
/*    B is Holland (1980) 'peakedness' scaling parameter
/*
/*&sv .B = 1.5          /*Very small cyclone - like Tracy
/*&sv .B = 1            /*Very large cyclone - like Justin
/*&sv .B = 1.25         /*Average sized cyclone - like Ivor or Joy
/*
/*    Estimate B using constants suggested by McConochie et al 1999
/*
/*          This is a constant fitted to each region
/*
```

```
&sv .Ba = 7.3
/*
&sv .hpaterm = %.hpa% / 160
&sv .B = %.Ba% - %.hpaterm%
/*
/*    DONE
/*
/*    Set scalar variables that change with the count
/*
/*          Find change in pressure for secondary circulation
/*          (used to simulate TC embedded in a low pressure trough)
/*
&sv hpaterm2 = %.hpa% / 20
/*
/*          Use this if a secondary vortex is to be included
/*
/*&sv .deltaP2 = 1013 - 1005 + %hpaterm2%
/*
/*          Use this if including only a primary vortex
/*
&sv .deltaP2 = 0
&sv newterm2a = %.B% * %.deltaP2%
&sv .newterm2 = %newterm2a% / %.Pa%
/*
/*          Find change in pressure for primary circulation
/*
&sv .deltaP = %.ambientP% - %.hpa%
&sv term2a = %.B% * %.deltaP%
&sv .term2 = %term2a% / %.Pa%
/*
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program was killed due to error.
quit
```

```
/*CORIOLIS.AML
/*AML to calculate the Coriolis parameter at each cyclone eye position
/*
/*    Module to control program in case of error
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    The Coriolis parameter is defined as f=2*angular velocity of
/*    the earth*sin(latitude).
/*
/*          Set earthV in radians per second.
/*
&sv .earthV = 0.0000729
/*
/*          Calculate the parameter
/*
&sv .latrad = [angrad %.latitude%]
&sv .sinlat = [sin %.latrad%]
&sv .f = 2 * %.earthV% * %.sinlat%
&sv .sqrf = [calc %.f% * %.f%]
&sv .absf = [abs %.f%]
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program was killed due to error.
quit
```

```
/*SETUPGRID.AML
/*    AML to extract a separate grid for each cyclone position
/*
/*    Sets up error routine
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Sets AML variables
/*
&sv position = position
&sv temp = temp
&sv cov = place
&sv ext = .vat
&sv tempgrid = %temp%%.count%
&sv .sourcegrid = %position%%.count%
&sv .newcov = %cov%%.count%
/*
/*    Creates a coverage containing the current eye position, plus
/*    two points defining the larger study area
/*
reselect 1hrlypts %.newcov% point
RES $RECNO gt [the last eye position]
~
N
Y
ASELECT $RECNO = %.count%
~
N
N
/*
/*    Converts the coverage to a grid
/*
pointgrid %.newcov% %tempgrid% $RECNO
1000
Y
NODATA
/*
/*    Sets all values to null except the eye position
/*
grid
%.sourcegrid% = setnull(%tempgrid% ^= 1, %tempgrid%)
/*
/*    Kills the temporary grid
/*
kill (! %.newcov% %tempgrid% !) all
&type 'THE POSITION GRID IS COMPLETE'
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program was killed due to error.
quit
```

```
/*DISTANGLE.AML
/*  AML to calculate the Euclidean distance and angle between the
/*  selected site and the eye of the cyclone
/*
/*    Activate routine in case of error
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Sets variables
/*
&sv out = distance
&sv angle = angle
&sv .outgrid = %out%%.count%
&sv .anglegrid = %angle%%.count%
/*
/*    Finds distance and angle of each cell from the eye
/*
%.outgrid% = eucdistance(%.sourcegrid%, %.anglegrid%)
kill %.sourcegrid% all
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program is in error.
quit
```

```
/*SPEED.AML AML to calculate cyclone 10 metre wind speed
/*
/*    Set error routine
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
&sv speed = speed
&sv .v = %speed%%.count%
/*
/*    Adjust angle to measure from the site to the eye (rather
/*    than from the eye to the site)
/*
DOCELL
anglen := %.anglegrid% + 180
anglesite = con(anglen gt 360, anglen - 360, anglen)
/*
/*    Find Vc1 (uncorrected wind speed for primary vortex)
/*
ratiod := %.R% / %.outgrid%
DtoBterm := pow(ratiod, %.B%)
eterma := pow(%.e%, DtoBterm)
eterm := 1 / eterma
vcterm := DtoBterm * %.term2% * eterm
vc := pow(vcterm, 0.5)
vcsqr := vc * vc
/*
/*    Find Vc2 (uncorrected wind speed for primary + secondary vortex)
/*
ratiod2 := %.R2% / %.outgrid%
DtoBterm2 := pow(ratiod2, %.B%)
eterm2a := pow(%.e%, DtoBterm2)
eterm2 := 1 / eterm2a
vcterm2 := DtoBterm2 * %.newterm2% * eterm2
vc2 := pow(vcterm2, 0.5)
vc2sqr := vc2 * vc2
/*
/*    Correct winds for Coriolis Effect to find Vg
/*
sumvc := vcsqr + vc2sqr
sqrr := %.outgrid% * %.outgrid%
addrf := sqrr * %.sqrf% / 4
minusrf := %.outgrid% * %.absf% / 2
vgb := sumvc + addrf
vgc := pow(vgb, 0.5)
vg := vgc - minusrf
/*
/*    Correct wind speed for forward motion of the cyclone
/*
/*          Calculate anticlockwise angle between cyclone & eye and
/*          direction of forward motion of the cyclone (theta)
/*
theta1 := %.direction% - anglesite
theta = con(theta1 lt 0, theta1 + 360, theta1)
/*
/*          Correct for forward motion
/*
alpha1a := theta - 65
```

```
alpha1b := con(alpha1a gt 360, alpha1a - 360, alpha1a)
alpha1 := cos(alpha1b div deg)
alpha2 := 1 + alpha1
alpha3 := alpha2 / 2
alpha4 := alpha3 * %.vf%
vuf := vg + alpha4
/*
/*  Calculate boundary layer adjustment according to Vuf
/*
if (vuf < 6)
 gamma := 0.81
else
 if (vuf >= 6 & vuf < 19.5)
  gamma := 0.81 - (0.00293 * (vuf - 6))
 else
  if (vuf >= 19.5 & vuf < 45)
   gamma := 0.77 - (0.00431 * (vuf - 19.5))
  else
  gamma := 0.66
endif
/*
/*  Apply the correction
/*
%.v% = gamma * vuf
END
&type GRADIENT WINDS for the combined primary and secondary vortex are
done.
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program was killed due to error.
quit
```

```
/*DIR.AML
/*    AML in GRID to find the direction of the wind from the cyclone
/*    towards each cell in the grid.
/*
/*    Set up error routine
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Sets variables
/*
&sv Rfactor = %.R% * 1.2
&sv dir = dir
&sv .dirgrid = %dir%%.count%
DOCELL
/*
/*    Find uncorrected wind direction
/*
dir1 := anglesite + 90
dir := con(dir1 gt 360, dir1 - 360, dir1)
/*
/*
/*    Calculates correction factor (Beta) for cyclone motion
/*
if (%.outgrid% < %.R%)
 beta := 10 * (%.outgrid% / %.R%)
else
 if (%.outgrid% >= %.R% & %.outgrid% < %Rfactor%)
 beta := 75 * (%.outgrid% / %.R%) - 65
else
 beta := 25
endif
/*
/*    Applies correction factor to correct directions
/*
dirgrid := dir - beta
%.dirgrid% = con(dirgrid < 0, dirgrid + 360, dirgrid)
END
/*
/*    Exits the GRID module
/*
quit
&type Wind directions are complete.
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program was killed due to error.
quit
```

```
/*FINDREEFASPECT.AML
/*    AML to find the direction which each part of each reef faces.
/*    This is achieved by calculating the angle of each grid cell that
/*    defines the reef from the centroid of that reef
/*
/*    Error routine to stop the program immediately with any error
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Before running the AML, I did the following:
*
/*    1.  Dissolved internal boundaries between contiguous reefs
/*    2.  Converted this new coverage to a grid at 100 m resolution
/*        called 'reefg100'
/*    3.  Used the grid function 'zonalcentroid' to find the centroid
/*        of each reef, saved to a new grid called 'reefctr100'
/*
/*    Some reefs are irregularly shaped, resulting in a centroid
/*    that falls outside the reef itself.  These had to be altered manually
/*    for the program to run correctly.  To do this, I:
/*
/*    4.  Converted the grid 'reefctr100' to a point coverage which I
/*        edited manually in ArcView (moving centroids inside reefs).
/*    5.  Used the Arc command 'intersect' to attach the unique ID number
/*        of the dissolved reefs to each centroid.
/*    6.  Converted the edited reef centroids to a grid of 100 m resolution
/*        called 'reefctr100n' using the ID # from the dissolved reefs.
/*
/*    Step 5 was necessary because editing the reef centroids changed their
/*    order and they no longer matched reefg100.
/*
&sv out = raspect
grid
/*
/*    Starts iterative loop to find aspect for each reef separately
/*
&sv count = 1
&do &until %count% = 2729 [number of reefs + 1]
/*
/*          Sets variables
/*
 &sv oldcount = %count% - 1
 &sv outgrid = %out%%count%
 &sv oldoutgrid = %out%%oldcount%
/*
/*          Selects the reef centroid from which to measure the aspect
/*          A resolution of 100 is set to preserve the centroid location

 setcell 100
 reefctr = con(reefctr100n eq %count%, reefctr100n)
/*
/*          Creates a mask erasing everything except the current reef
/*
 mask = con(reefg100 eq %count%, reefg100)
 setmask mask
/*
/*          Finds aspect for the selected reef
```

```
/*
 aspect = eucdirection(reefctr)
 setmask off
/*
/*    Reverses the aspect direction (to show the position of each cell
/*    with respect to the centroid).  Saves the result at 500 m resolution
/*    to save space and reduce processing time.  Adds the new reef to the
/*    reefs already complete.
/*
 setcell 500
 DOCELL
  a := con(isnull(aspect), 0, aspect + 180)
  b := con(a gt 360, a - 360, a)
  %outgrid% = %oldoutgrid% + b
 END
/*
/*    Kills intermediate files
/*
 kill (! reefctr mask aspect %oldoutgrid% !) all
/*
/*    Advances the count
/*
 &sv count = %count% + 1
 &type Another reef is complete.
&end
/*
/*    End of the iterative loop.
/*
&type The analysis is complete for the entire GBR.
quit
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program is in error.
```

```
/*FINDVN.AML
/*    AML to correct the moving wind speed estimates for within-reef
/*    shelter using the cos as a dissipative function as per Done 1992b
/*
/*
/*    Set variables
/*
&sv d = dir
&sv alpha = alpha
&sv v = speed
&sv vn = vn
grid
/*
/*    Use a mask to hide all but the inside of reefs
/*
setmask mask
&sv count = 1
/*
/*    Start iterative loop to adjust the wind speed for each cyclone
/*    position at a time
/*
&do &until %count% = [number of cyclone eye positions + 1]
/*
/*    Adjust the wind speed
/*
  &sv dgrid = %d%%count%
  &sv alphagrid = %alpha%%count%
  &sv vgrid = %v%%count%
  &sv outvn = %vn%%count%
/*
/*    sets resolution to 500 metres to retain small reefs
/*
  setcell 500
  DOCELL
/*
/*    Finds the angle between the direction of TC wind approach and the
/*    site (doesn't matter which side of N, because cos result won't vary)
/*    'reefaspect' is a grid showing which way each cell in each reef faces
/*
%alphagrid% := abs(reefaspect - %dgrid%)
/*
/*    Reduces the wind energy with distance around the reef from the site
/*
    uvtemp := %vgrid% * cos(%alphagrid% div deg)
    %outvn% = con(uvtemp lt 0, 0, uvtemp)
  END
/*
/*    Advances the count
/*
&sv count = %count% + 1
&end
/*
/*    End of the iterative loop
/*
quit
```

```
/*GETEXPOSURE.AML
/*    AML to find the distance from reef sites across the entire GBR
/*    to the nearest obstacle in all directions, measured every 7.5
/*    degrees.  Particular directions, or ranges of directions, can
/*    then be averaged to estimate the exposure of that site to local
/*    wind seas during a cyclone or during ambient conditions.
/*
/*    Before I ran this program, I did the following:
/*
/*    1.  Built the dissolved reef coverage as a line coverage.
/*    2.  Used an ArcView extension to create a point shapefile
/*        containing points spaced every 1 km along each reef outline.
/*        The extension 'Poly2pts.avx' was provided by W. Huber (2002)
/*        at http://arcscripts.esri.com.
/*    3.  Converted the new shapefile to a coverage called 'reefpt1km'.
/*    4.  Ran the Arc command 'addxy' to establish x/y coordinates for
/*        each of the points in 'reefpt1km'.
/*
/*
/*    Sets up program to stop the analysis in case of error
/*
&severity &warning &routine winderror
&severity &error &routine winderror
/*
/*    Adds items to record the fetch directions to be calculated
/*
&sv dir = 0
&sv f = f
&do &until %dir% = 360
  &sv item = %f%%dir%
  additem reefpt1km.pat reefpt1km.pat %item% 4 12 f 3
  &sv dir = %dir% + 7.5
&end
&type New items have been added to sites.
/*
&sv count = 1
/*
/*    Start iterative loop to do each reef site at a time
/*
&do &until %count% = [number of reef points + 1]
/*
/*    Reads in the x/y coordinates of the site
/*
  &sv .mastercount = %count%
  tables
    select reefpt1km.pat
    &sv .x1 = [show RECORD %count% x-coord]
    &sv .y1 = [show RECORD %count% y-coord]
  quit
/*
/*    Constructs fetch lines in a range of directions for the site
/*
  &sv site = reef
  &sv .outsite = %site%%count%
  &run getbyangle.aml
/*
/*    Combine all the fetch lines for the site into a single coverage
/*
```

```
   &run mergelines.aml
/*
/*    Advance the count
/*
   &sv count = %count% + 1
&end
/*
/*    End of iterative site loop
/*
&type The analysis is complete.
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program is in error.
quit
```

```
/*GETBYANGLE.AML
/*    AML to create lines which indicate the distance from a site
/*    to the nearest obstacle in all directions, every 7.5 degrees
/*
/*    Error routine to stop the program immediately with any error
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Sets the length of the fetch line to be created initially
/*    (Distance beyond 50 km is assumed to be unlimited fetch)
/*
&sv L = 50000
/*
/*    Start iterative loop: directions to consider for that site
/*
 &sv .alpha = 0
 &do &until %.alpha% = 360
/*
/*          Sets angle so it is referenced to the x axis (90 degrees)
/*
 &type Resetting angle to reference from the x axis
 &if %.alpha% = 0 &then &do
  &sv alphar = 90
  &end
 &else &do
  &sv tempa = %.alpha% - 360
  &sv alphar = 90 - %tempa%
 &end
/*
/*          Calculates the x/y coordinates of the endpoint
/*
  &sv alpharad = [angrad %alphar%]
  &sv lcosa = %L% * [cos %alpharad%]
  &sv lsina = %L% * [sin %alpharad%]
  &sv .x2 = %.x1% + %lcosa%
  &sv .y2 = %.y1% + %lsina%
/*
/*          Creates the fetch line from the start point to end point
/*
  generate fetchline
  copytics reefpt1km
  lines
  1
  %.x1% %.y1%
  %.x2% %.y2%
  end
  end
  quit
  build fetchline (! line node !)
/*
/*    Erases the parts of the line that fall inside an obstacle
/*
  erase fetchline barriers splitline line
/*
/*    Checks that 'splitline' is not zero length
/*    (eg, when the entire fetch line is located inside an obstacle)
/*
```

```
  ap
    asel splitline arc
    &sv .num = [EXTRACT 1 [SHOW SELECT splitline arc]]
/*
/*          The variable '.num' = # of segments in 'splitline'
/*
  quit
/*
/*          If '.num' = 0, uses the original unbroken fetch line
/*
  &sv f = f
  &sv newalpha = %.alpha% * 10
  &sv .outfetch = %.outsite%%f%%newalpha%
  &if %.num% = 0 &then &do
    &type The entire fetch line is blocked by obstacles
    &type Using the full fetch line instead
    copy fetchline %.outfetch%
    kill (! fetch split !)line all
    &sv .alpha = %.alpha% + 7.5
  &end
  &else &do
/*
/*    Retains only those segments originating from the site
/*
    addxy splitline node
    &run getsegment.aml
/*
/*    If the site is inside the barrier (no line created), create one that
/*    is the same as the previous one (will disappear once appended)
/*
    &sv fetchok = [exists %.outfetch% -cover]
    &if %fetchok% = .TRUE. &then &type The line exists.
    &else &do
      &type Creating a line the same as the previous one to fool 'append'
      &sv oldalpha = %.alpha% - 7.5
      &sv oldalpha1 = %oldalpha% * 10
      &sv f = f
      &sv lastcov = %.outsite%%f%%oldalpha1%
      &sv lastcovok = [exists %lastcov% -cover]
      &if %fetchok% = .FALSE. &then copy splitline %.outfetch%
    &end
  kill (! split fetch !)line all
/*
/*    Advances the angle by the specified increment shown below
/*
  &sv .alpha = %.alpha% + 7.5
  &lv .alpha
  &end
 &end
 &return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program is in error.
quit
```

```
/*GETSEGMENT.AML
/*    AML to delete segments of fetch lines that are beyond the first
/*    barrier (do not share start-node with the original fetch line)
/*
/*    Error routine to stop the program immediately with any error
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Starts a loop to find the one correct segment to keep
/*
&sv count = 1
&sv endcount = %.num% + 1
&do &until %count% = %endcount%
/*
/*          Splits the segments to check each start-node
/*
  reselect splitline slice line
  RES $RECNO = %count%
  ~
  N
  N
/*
/*          Checks the x/y coords of the start-node of that segment
/*          (checks both nodes because the position of the start-node
/*           varies)
/*
  tables
    select slice.nat
    &sv .nodex1st = [show RECORD 1 x-coord]
    &sv .nodey1st = [show RECORD 1 y-coord]
    &sv .nodex2nd = [show RECORD 2 x-coord]
    &sv .nodey2nd = [show RECORD 2 y-coord]
  quit
/*
/*    Saves it if it matches, deletes it otherwise
/*
  &if %.nodex1st% = %.x1% and %.nodey1st% = %.y1% &then &do
    &type This is the correct fetch line.
    &sv newitem = %f%%.alpha%
    tables
      select slice.aat
      &sv length = [show RECORD 1 length]
      select reefpt1km.pat
      resel $RECNO = %.mastercount%
      calc %newitem% = %length%
    quit
    copy slice %.outfetch%
    kill slice all
    &sv count = %.num%
  &end
  &else &if %.nodex2nd% = %.x1% and %.nodey2nd% = %.y1% &then &do
    &type This is the correct fetch line.
    &sv newitem = %f%%.alpha%
    tables
      select slice.aat
      &sv length = [show RECORD 1 length]
      select reefpt1km.pat
```

```
      resel $RECNO = %.mastercount%
      calc %newitem% = %length%
    quit
    copy slice %.outfetch%
    kill slice all
    &sv count = %.num%
   &end
   &else &do
     &type This is a superfluous line.
     kill slice all
   &end
/*
/*    Advances the count
/*
  &sv count = %count% + 1
  &type This segment is complete.
&end
/*
/*    End of the iterative loop
/*
&type All superfluous segments have been deleted.
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program is in error.
quit
```

```
/*MERGELINES.AML
/*    AML to combine a series of fetch lines taken at 7.5 degree intervals
/*    into a single line coverage for that site.
/*
&severity &warning &routine winderror
&severity &error &routine winderror
/*
/*    Establish the input coverage names, 1 - 360 at 7.5 degree intervals
/*    (note: names are * by 10 because names can't have a decimal place)
/*
&sv f = f
&sv out = %.outsite%%f%
&sv n1 = 0
&sv in1 = %out%%n1%
&sv n2 = 75 * 1
&sv in2 = %out%%n2%
&sv n3 = 75 * 2
&sv in3 = %out%%n3%
&sv n4 = 75 * 3
&sv in4 = %out%%n4%
&sv n5 = 75 * 4
&sv in5 = %out%%n5%
&sv n6 = 75 * 5
&sv in6 = %out%%n6%
&sv n7 = 75 * 6
&sv in7 = %out%%n7%
&sv n8 = 75 * 7
&sv in8 = %out%%n8%
&sv n9 = 75 * 8
&sv in9 = %out%%n9%
&sv n10 = 75 * 9
&sv in10 = %out%%n10%
&sv n11 = 75 * 10
&sv in11 = %out%%n11%
&sv n12 = 75 * 11
&sv in12 = %out%%n12%
&sv n13 = 75 * 12
&sv in13 = %out%%n13%
&sv n14 = 75 * 13
&sv in14 = %out%%n14%
&sv n15 = 75 * 14
&sv in15 = %out%%n15%
&sv n16 = 75 * 15
&sv in16 = %out%%n16%
&sv n17 = 75 * 16
&sv in17 = %out%%n17%
&sv n18 = 75 * 17
&sv in18 = %out%%n18%
&sv n19 = 75 * 18
&sv in19 = %out%%n19%
&sv n20 = 75 * 19
&sv in20 = %out%%n20%
&sv n21 = 75 * 20
&sv in21 = %out%%n21%
&sv n22 = 75 * 21
&sv in22 = %out%%n22%
&sv n23 = 75 * 22
&sv in23 = %out%%n23%
```

```
&sv n24 = 75 * 23
&sv in24 = %out%%n24%
&sv n25 = 75 * 24
&sv in25 = %out%%n25%
&sv n26 = 75 * 25
&sv in26 = %out%%n26%
&sv n27 = 75 * 26
&sv in27 = %out%%n27%
&sv n28 = 75 * 27
&sv in28 = %out%%n28%
&sv n29 = 75 * 28
&sv in29 = %out%%n29%
&sv n30 = 75 * 29
&sv in30 = %out%%n30%
&sv n31 = 75 * 30
&sv in31 = %out%%n31%
&sv n32 = 75 * 31
&sv in32 = %out%%n32%
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&sv in34 = %out%%n34%
&sv n35 = 75 * 34
&sv in35 = %out%%n35%
&sv n36 = 75 * 35
&sv in36 = %out%%n36%
&sv n37 = 75 * 36
&sv in37 = %out%%n37%
&sv n38 = 75 * 37
&sv in38 = %out%%n38%
&sv n39 = 75 * 38
&sv in39 = %out%%n39%
&sv n40 = 75 * 39
&sv in40 = %out%%n40%
&sv n41 = 75 * 40
&sv in41 = %out%%n41%
&sv n42 = 75 * 41
&sv in42 = %out%%n42%
&sv n43 = 75 * 42
&sv in43 = %out%%n43%
&sv n44 = 75 * 43
&sv in44 = %out%%n44%
&sv n45 = 75 * 44
&sv in45 = %out%%n45%
&sv n46 = 75 * 45
&sv in46 = %out%%n46%
&sv n47 = 75 * 46
&sv in47 = %out%%n47%
&sv n48 = 75 * 47
&sv in48 = %out%%n48%
/*
/*    Appends the new coverage
/*
append %out%
%in1%
%in2%
%in3%
%in4%
```

```
%in5%
%in6%
%in7%
%in8%
%in9%
%in10%
%in11%
%in12%
%in13%
%in14%
%in15%
%in16%
%in17%
%in18%
%in19%
%in20%
%in21%
%in22%
%in23%
%in24%
%in25%
%in26%
%in27%
%in28%
%in29%
%in30%
%in31%
%in32%
%in33%
%in34%
%in35%
%in36%
%in37%
%in38%
%in39%
%in40%
%in41%
%in42%
%in43%
%in44%
%in45%
%in46%
%in47%
%in48%
~
Y
Y
build %out% line
/*
/*    Kills the individual fetch lines
/*
kill %out%(! %n1% %n2% %n3% %n4% %n5% %n6% %n7% %n8% %n9% %n10% !) all
kill %out%(! %n11% %n12% %n13% %n14% %n15% %n16% %n17% %n18% %n19% %n20%!)
all
kill %out%(! %n21% %n22% %n23% %n24% %n25% %n26% %n27% %n28% %n29% %n30% !)
all
kill %out%(! %n31% %n32% %n33% %n34% %n35% %n36% %n37% %n38% %n39% %n40% !)
all
```

```
kill %out%(! %n41% %n42% %n43% %n44% %n45% %n46% %n47% %n48% !) all
&type Fetch lines have been merged.
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program is in error.
quit
```

```
/*STOREOBS.AML
/*
/*AML to extract wind speed and direction values for each hourly cyclone
/*    position and write them to an attribute table
/*
/*    Error routine to stop the program immediately with any error
/*
&severity &warning &ignore
&severity &error &routine winderror
/*
/*    Start iterative loop, doing one site at a time
/*
&sv .sitecount = 1
&do &until %.sitecount% = [number of reef sites of interest + 1]
 &lv .sitecount
/*
/*    Reads x/y coordinates of the site
/*
tables
  select sites.pat
  &sv xcoord = [show RECORD %.sitecount% x-coord]
  &sv ycoord = [show RECORD %.sitecount% y-coord]
quit
  /*
  /*  Iterative loop to do one cyclone position at a time
  /*
&sv .tccount = 1
&do &until %.tccount% = [number of cyclone eye positions + 1]
   &type Working through cyclone positions now
/*
/*          Sets variables
/*
   &sv d = d
   &sv s = s
   &sv ditem = %d%%.tccount%
   &sv sitem = %s%%.tccount%
/*
/*          Adds the items in which to store the data (1st iteration only)
/*
  &if %.sitecount% = 1 &then &do
     additem speedP.pat speedP.pat %sitem% 4 12 F 3
     additem dirP.pat dirP.pat %ditem% 4 12 F 3
     &type New items have been added.
   &end
   &else &type Items already exist.
/*
/*          Reads the speed and direction values for the site
/*
/*
/*                Sets variables
/*
  &sv v = speed
  &sv inv = %v%%.tccount%
  &sv d = dir
  &sv ind = %d%%.tccount%
/*
/*                Reads the values
/*
```

```
  grid
    &sv .v = [show cellvalue %inv% %xcoord% %ycoord%]
    &sv .d = [show cellvalue %ind% %xcoord% %ycoord%]
  quit
  /*
  /*              Writes the values to the items
  /*
  tables
     select speedP.pat
     reselect $RECNO = %.sitecount%
     calc %sitem% = %.v%
     select dirP.pat
     reselect $RECNO = %.sitecount%
     calc %ditem% = %.d%
  quit
  &sv .tccount = %.tccount% + 1
 &end
 /*
 /*   End of cyclone loop
 /*
 &sv .sitecount = %.sitecount% + 1
 &type Another cyclone position is complete.
&end
/*
/*    End of reef sites loop
/*
&type The program is complete.
&return
/*
/*  routine to stop the program and quit ArcInfo in case of error
/*
&routine winderror
&severity &error &ignore
&messages &on
&return &error The program is in error.
quit
```

```
/*TCUCIRCLES.AML
/*    AML to visualise the uncertainty of cyclone eye positions over an
entire cyclone
/*
/*
/*    Note: before this AML was run, uncertainty estimates were entered
/*    into a new item called 'udistkm' in ArcView GIS.  The estimates were
/*    based on the method used by the Bureau of Meteorology to establish
/*    the eye position and Holland 1981:
/*
/*    BOM code   Description                    U Distance
/*          1    no sat, no rad, no obs         300 km
/*          2    no sat, no rad, obs only       200 km
/*          3    sat;  no clear eye             100 km
/*          4    sat;  clearly defined eye      75  km
/*          5    aircraft radar report          50  km
/*          6    land-based radar report        50  km
/*          7    sat & rad & obs                25  km
/*          8    report inside eye              10  km
/*
/*    Set variables that don't change with the count
/*
&sv count = 2
/*
/*    Note:  do the first iteration manually
/*
&sv circle = circle
&sv pt = point
&sv union = u
&sv buff = b
&sv ext = .pat
&sv ext1 = #
&sv ext2 = -id
/*
/*    Start iterative loop to do each original eye position separately
/*
&do &until %count% = [number of eye positions + 1]
/*
/*          Set variables that vary with the count
/*
 &sv backcount = %count% - 1
 &sv circlen = %circle%%count%
 &sv backcircle = %union%%backcount%
 &sv unionn = %union%%count%
 &sv ptn = %pt%%count%
 &sv item = %buff%%count%
 &sv addfile = %circlen%%ext%
 &sv ufile = %unionn%%ext%
 &sv drop1 = %circle%%count%%ext1%
 &sv drop2 = %circle%%count%%ext2%
 &sv drop3 = %union%%backcount%%ext1%
 &sv drop4 = %union%%backcount%%ext2%
/*
/*          Isolates the current eye position of interest
/*
 reselect [cyclone name] %ptn% point
  RESEL $RECNO = %count%
  ~
```

```
  N
  N
/*
/*          Creates a circle to represent positional uncertainty
/*
 buffer %ptn% %circlen% udistkm # # 2.26 point round full
 additem %addfile% %addfile% %item% 2 2 I # inside
 tables
  select %addfile%
  reselect inside = 100
  calc %item% = 1
 quit
 union %backcircle% %circlen% %unionn% 2.26 join
 tables
  select %ufile%
  calc count = count + %item%
 quit
 dropitem %ufile% %ufile% (! %item% %drop1% %drop2% %drop3% %drop4% !)
 kill (! %backcircle% %ptn% %circlen% !) all
 &sv count = %count% + 1
&end
```

# APPENDIX 3: Summary of cyclone damage observations

Detailed field data was available for cyclones Ivor, Joy and Justin (surveyed as part of this thesis). Additional, but less detailed data, was available for cyclones Althea and Celeste. This appendix first summarises the key terms used to describe cyclone damage (and how they were derived) throughout this thesis. It then presents a description of the path taken by each of the cyclones for which field data has been collected and a summary of the resultant patterns of damage.

## *A3.1 Summary of cyclone damage terminology used in this thesis*

Eight basic **types of cyclone wave damage** are generally defined for the GBR (Van Woesik et al 1991, Done et al 1991, Ayling 1991): coral breakage, debris scars, soft coral stripping, trenching, sand/debris movement, removal of intact slabs, dislodgement of massive corals and exfoliation. These can be classified according to the magnitude of wave energy required to produce them, ranging from **low-energy to high-energy** (see Figure 1.17 and 1.18 in chapter 1). During each field survey, the severity of cyclone damage of each type was recorded in a **damage score** that ranged from 0 to 5 (with the exception of cyclone Justin, where scores were originally recorded on a scale from 0 to 3 and then transformed to a scale of 0 to 5). This score was based on the extent to which the incidence of damage was widespread (high, damage score = 5) or localised (low, damage score = 1) across each site. The severity of damage observed individually for each type was further classified as high (widespread, damage score $\geq$ 3) or low (localised, damage score < 3). To summarise this information across the eight types of damage, the **maximum severity of damage** (maximum damage score across all eight damage types) and the **total damage score**

(sum of damage scores for all eight damage types) were also calculated. The severity of damage across all types was further classified as high (damage score $\geq$ 15), low (damage score 5-15) or very low (damage score < 5). In addition, the total damage score was tabulated separately for high-energy (**total damage score across high-energy types**) and low-energy damage types (**total damage score across low-energy types**). Finally, to enable the use of less detailed data from cyclones Althea and Celeste, this information was also simplified to indicate the **presence versus absence** of damage for each type, as well as for severe damage of any type. The latter is defined by a total damage score $\geq$ 15 (the same as 'high' damage severity defined in Chapter 3).

### *A3.2 Cyclone paths and patterns of damage*

CYCLONE IVOR

Cyclone Ivor crossed the GBR on 19 March 1990 from 0 to 1500 UTC (Figure A3.1), gradually weakening as it approached the coast. Ivor passed near reefs located north of Cooktown while at moderate (category 2) to severe (category 3) intensity. Though the cyclone later re-entered the GBR near reefs off the coast of Cairns, and tracked southward to just past Townsville, it had weakened to below cyclone strength by that stage (Ready and Woodcock 1992).

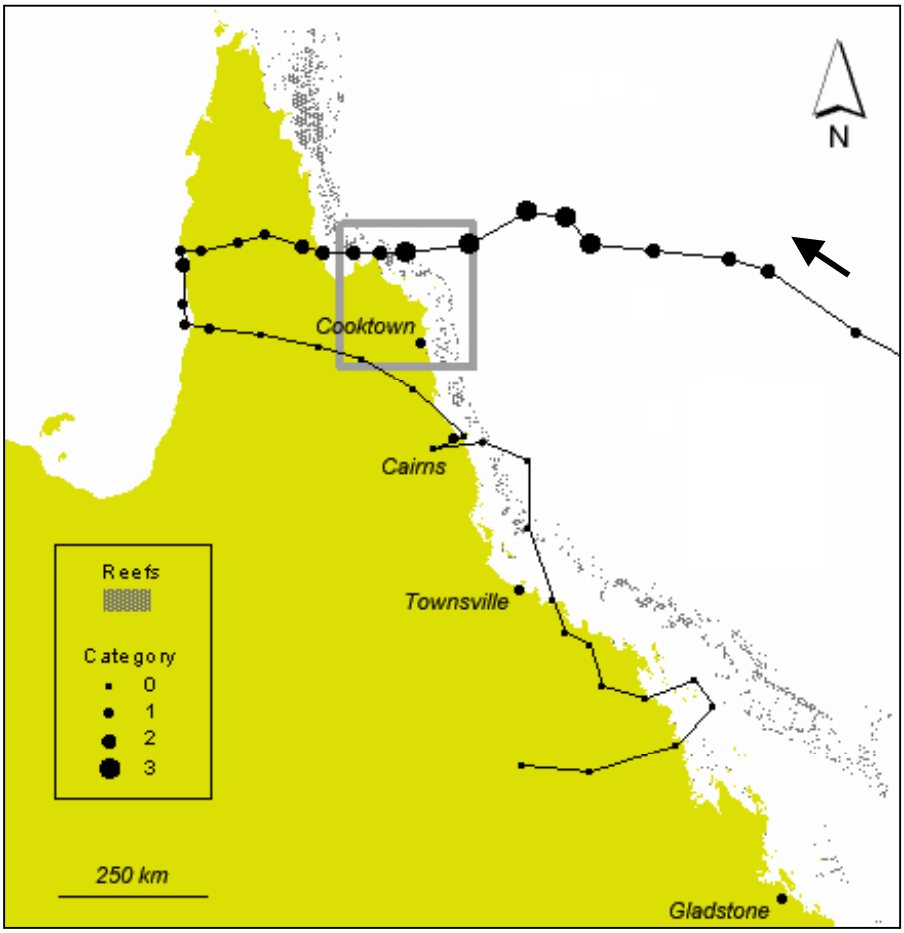



**Figure A3.1:** Track of cyclone Ivor (March 1990). Reef sites surveyed by Done et al 1991 are located within the thick gray box. The cyclone moved in the direction of the arrow.

Done et al 1991 surveyed a total of 63 sites on 33 reefs following cyclone Ivor (Figure A3.2) - three of these reefs (Carter, Eyrie and Lizard Island) were surveyed immediately before the cyclone as well (Van Woesik et al 1991). Sites were qualitatively assessed for wave damage on a scale of 0 to 5 across a range of categories. Sites were surveyed both to the left (south) and right (north) of the nominal cyclone path, in areas with a range of exposure to ambient and cyclone energy. Observations were also made for a range of slopes (eg, reef flat, exposed reef slope).

Evidence of wave damage was found up to 100 km away from the nominal path, though most high-energy damage (dislodgement of massives, exfoliation of the reef matrix) was found within ~50 km (Done 1992b). Damage severity ranged from complete devastation to none, with a greater proportion of damage concentrated at exposed reef fronts rather than sheltered back sites and on medium rather than flat or steep slopes.

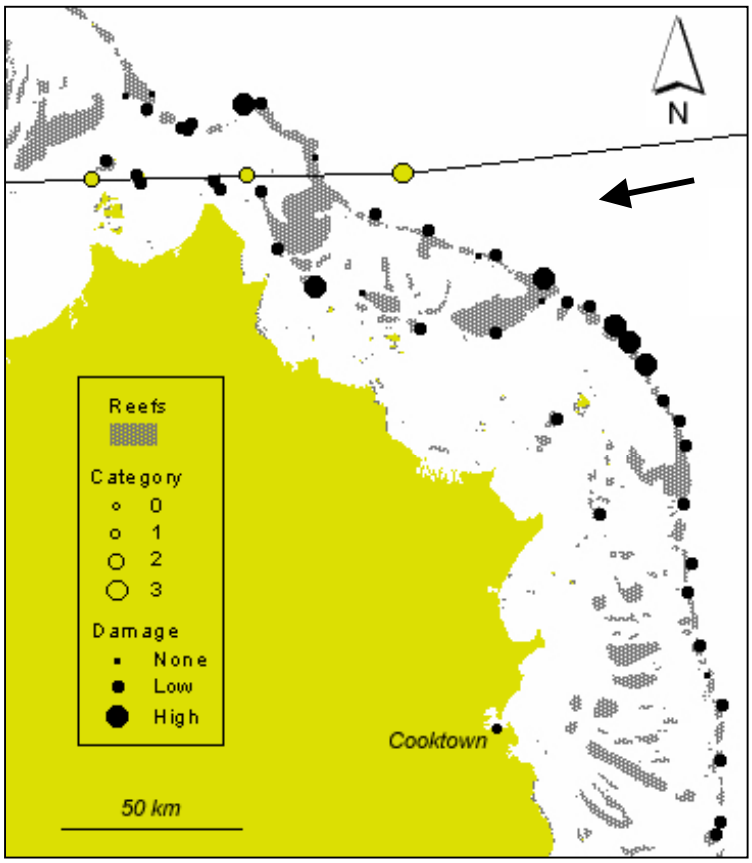



**Figure A3.2:** Sites surveyed by Done et al 1991 following cyclone Ivor (1990). The cyclone moved in the direction of the arrow.

## CYCLONE JOY

Tropical cyclone Joy tracked near the GBR from 22 to 27 December 1990 (Figure A3.3). While the cyclone eventually made landfall near Townsville on 27 December at 0 hours UTC, it had already weakened considerably by that time (Bannister and Smith 1993). However, Joy passed within 100 km of Cairns, and 80 km of Green Island, while severe (category 3 and 4) between 22 December at 1800 UTC and 24 December at 1800 UTC. Reefs located offshore between Cairns and Cooktown were thus likely exposed to significant wave energy, even though all of the sites were located on the right (weaker side) of the cyclone path.

Ayling (1991) surveyed 186 sites on 33 reefs located offshore from Cairns to Cooktown following cyclone Joy (Figure A3.4). No reefs were surveyed offshore from Townsville where the weakened cyclone actually crossed the coast. Sites were qualitatively assessed for wave damage on a scale of 0 to 5 across a range of categories. Though all of the surveyed sites were located on the weaker (right) side of the cyclone path, they were located adjacent to where the cyclone tracked closest to the coast while at its peak intensity. A northerly, southerly and central site was surveyed on each reef, for both an exposed (front) and sheltered (back) position, but the slope of the sites was not recorded. The majority of the high-energy damage was concentrated within about 100 km of the most intense eye positions of the cyclone. Lower energy damage was scattered to both the north and south of these sites for another ~100 km. As with cyclone Ivor, the severity of damage ranged from complete devastation to none.

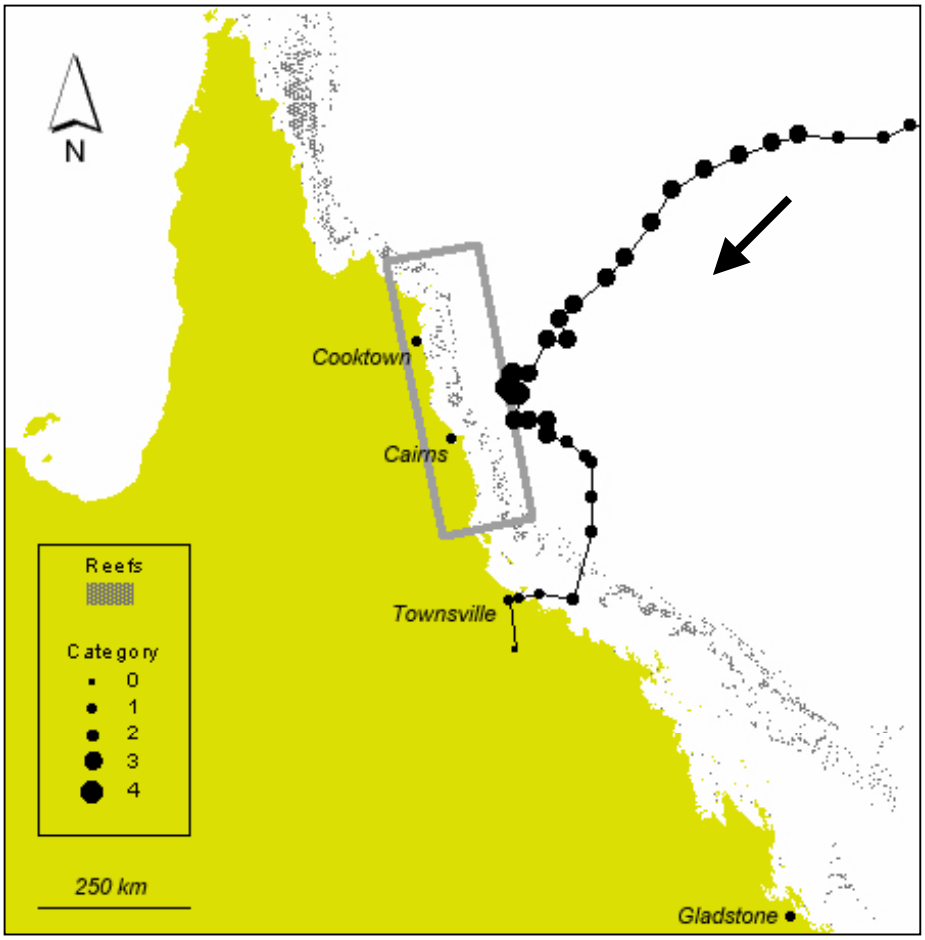



**Figure A3.3:** Track of cyclone Joy (December 1990). Reef sites surveyed by Ayling 1991 are located within the thick gray box.

In general, damage was more severe at reef sites located near the cyclone path when it was most intense (panels 3-4), though scattered low-energy damage extended 100s of km further to the north and south. No damage was found beyond about 200 km of the most intense section of the path. In general, sites were more likely to sustain damage if located on the high-energy reef front.

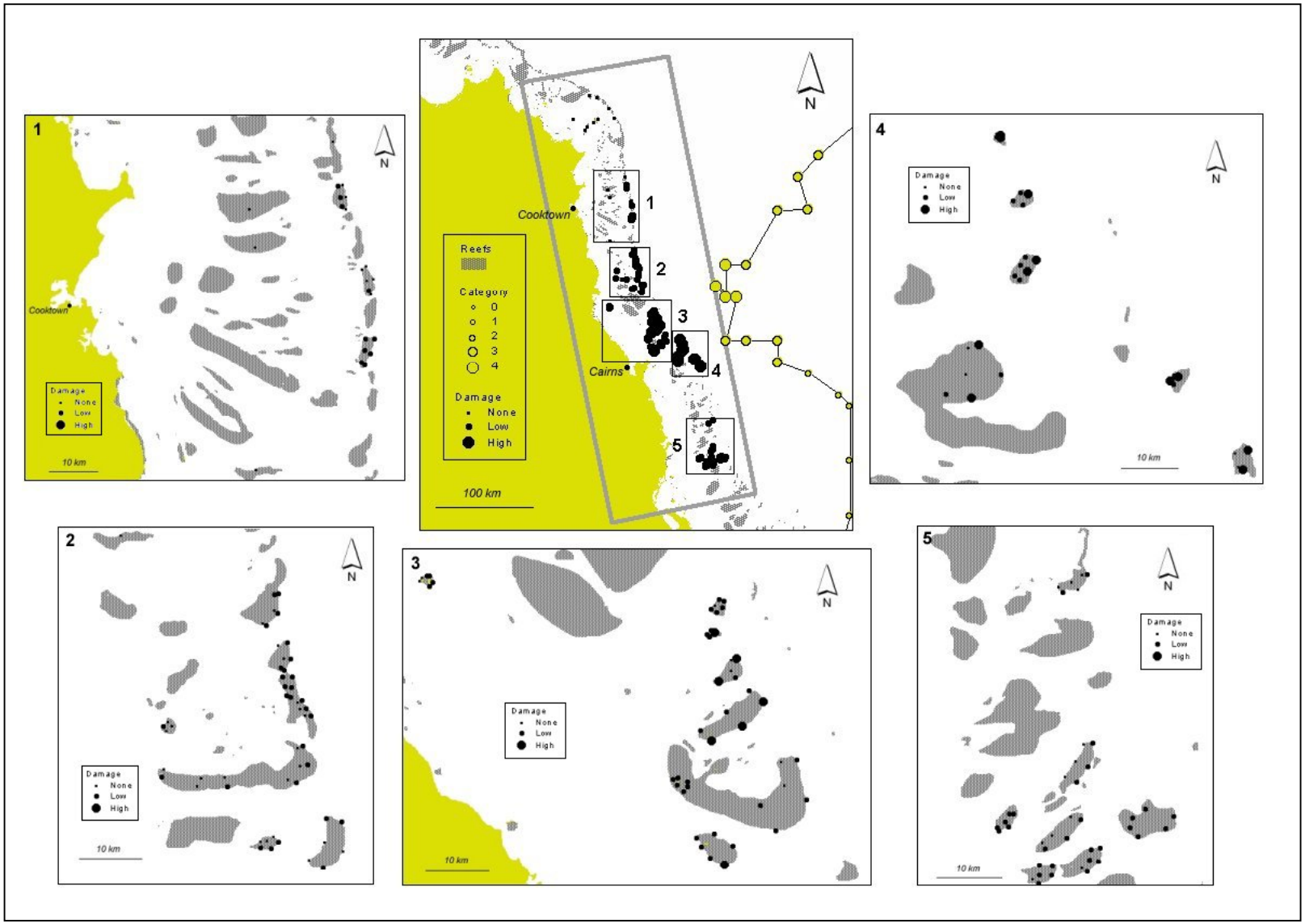



**Figure A3.4:** Sites surveyed by Ayling 1991 following cyclone Joy.

CYCLONE JUSTIN

Cyclone Justin (Figure A3.5) was an unusually long-lived (6-23 March 1997) system, which, in its early stages in the Coral Sea, was also large and slow moving (Hanstrom et al 1999).

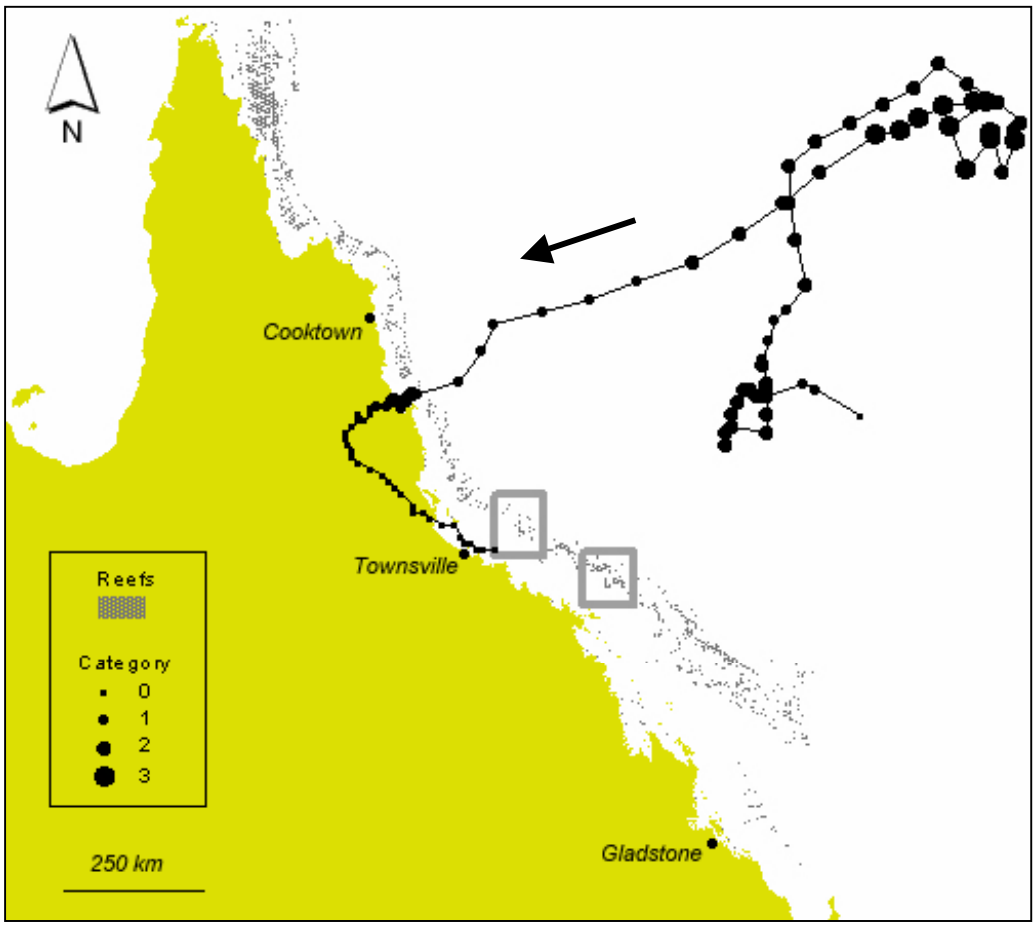



**Figure A3.5:** Track of cyclone Justin (March 1997). Reef sites surveyed by this author (and a team from GBRMPA and AIMS) are located within the thick grey boxes.

Meteorologists estimated its early radius of maximum winds to be around 100 km (compared to a typical eye width of 30 km). Justin was of low intensity (category 2) at this stage. However, it was nearly stationary for almost a week, which allowed large waves to build up and propagate through gaps in the GBR, affecting areas far

distant (100s of km) from the cyclone eye. Justin reached maximum intensity (category 4) while located offshore from Papua New Guinea, where it caused major damage on land (Hanstrum et al 1999). The cyclone weakened as it approached the Queensland coast, temporarily intensifying to category 2 while making landfall at Cairns. It then weakened as it moved over land, entering the sea again and re-forming briefly just north of Townsville (Hanstrum et al 1999).

As part of this thesis, the author and a team of reef scientists from GBRMPA and AIMS surveyed sites located offshore from Townsville and in the Whitsunday Islands region about three weeks after the final decay of the cyclone. The field sites were concentrated in the south central GBR, where high wave energy was reported along the coast during the early phase of the cyclone. Sites were qualitatively assessed for wave damage on a scale from 0 to 3 across a range of categories (these were later converted to the 0-5 scale used for cyclones Ivor and Joy). Sites located at both high-energy reef fronts and sheltered backs were examined. Slope was qualitatively recorded. We surveyed 29 sites on 5 reefs offshore from Townsville (Figure A3.6). No high-energy damage was found, although low-energy damage was widespread (see chapter 1, Figures 1.16 and 1.17), except on Little Broadhurst and Davies Reefs.

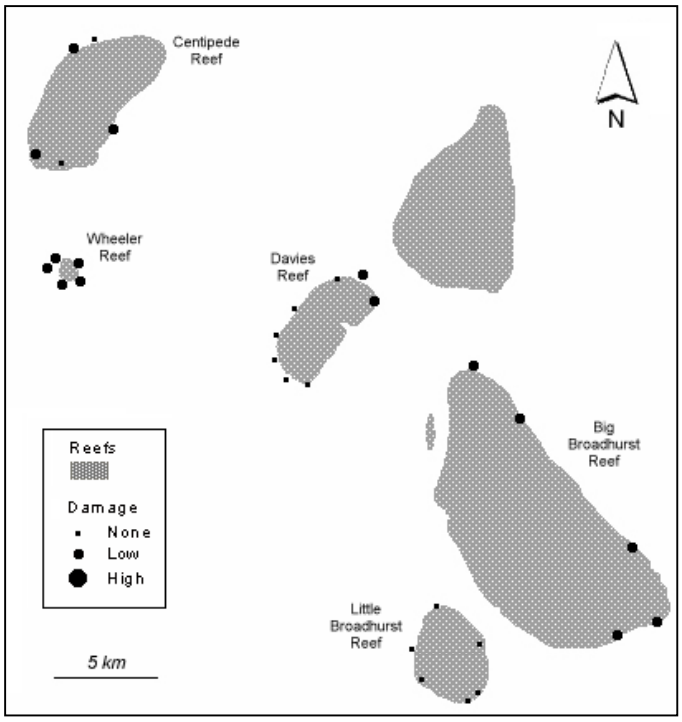



**Figure A3.6:** Sites surveyed offshore from Townsville following cyclone Justin as part of this thesis.

We also surveyed 25 sites on 7 reefs in the Whitsunday Islands region (Figure A3.7). Sites showed mainly scattered low-energy damage, with the exception of one site which was completely devestated. This site, located at the south face of Oublier Reef, must have experienced heavy wave action as massive corals greater than 1 metre in size were dislodged, and entire slopes were stripped bare of coral, with extensive piles of dead coral. Oublier Reef presented a dramatic progression from this site to one that was virtually untouched only a few kilometres away. Because the potential region that could be affected by Justin was vast and impossible to survey completely, a reef damage questionnaire was distributed to all tourist permit holders in the GBR Marine Park (Appendix 1). Of the 33 responses received, observations for 55 sites on 37 reefs were useable (the position of the site could be identified reasonably clearly).

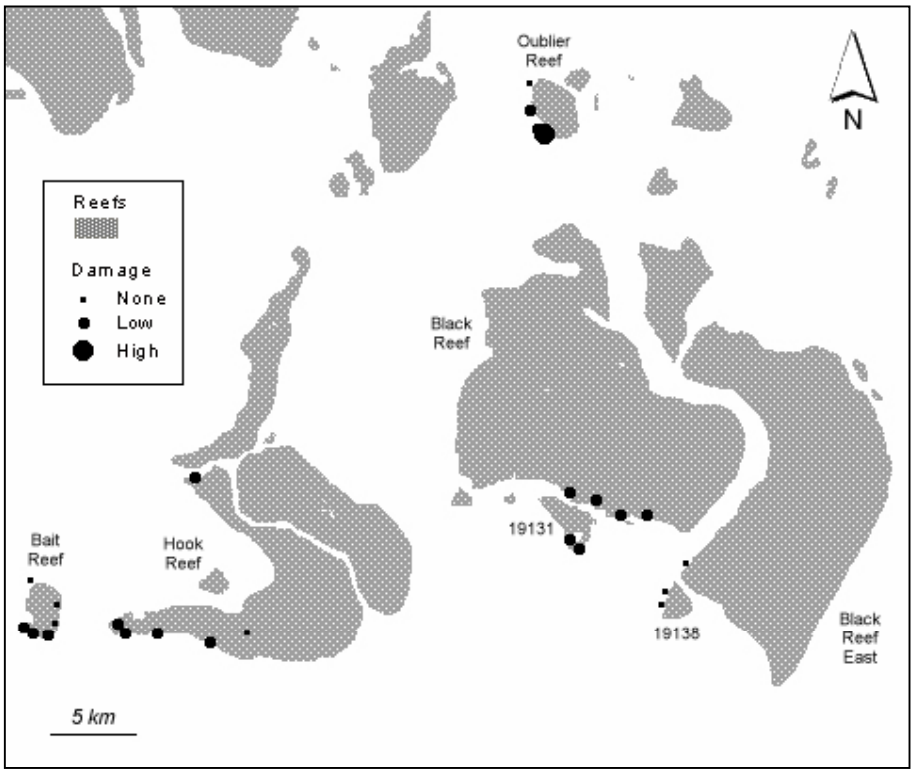



**Figure A3.7:** Sites surveyed in the Whitsunday Islands region following cyclone Justin (1997) as part of this thesis.

Reports of wave damage from cyclone Justin span much of the length of the GBR, from as far north as Mackay Reef (offshore from Cooktown) to as far south as Lady Musgrave Island - south of Gladstone (Figure A3.8). Because tourist operators rarely visit the far north, only one reef north of Cooktown was visited (Sykes Reef). No damage was reported there - the cyclone path was distant from that location at all times.

Tourist operators frequently visit reefs located offshore from Cooktown and Cairns. Of the 20 reefs for which questionnaires received (Figure A3.8, panel 1), low-energy damage (mostly breakage) was observed at Green Island Reef, Hedley Reef, Mackay Reef, Michaelmas Cay Reef, Norman Reef and Opal Reef, all of which were located within ~100 km of the cyclone path as it approached Cairns at low intensity (category

2). High-energy damage (dislodgement) was reported at Fitzroy and Normanby Island Reefs, both of which were located within 50 km of the left (strong) side of the path. Further, the Norman Reef pontoon broke free from its moorings during the cyclone, breaking and dislodging corals (Ayling and Ayling 1997).

For reefs located between Townsville and the Whitsunday Islands region, respondents reported visits to 13 reefs following cyclone Justin (Figure A3.8, panel 2). Some damage (broken corals and rubble movement) was reported at Brambles and Britomart Reefs.

No other damage was reported offshore from Townsville, even though the cyclone passed quite close to reefs in this area (particularly those located along Magnetic Island and the Palm Island group) as it re-formed weakly during its latter stages. In contrast, high-energy damage (dislodged and broken corals, trenching and rubble movement) was reported for the Whitsunday Islands region at Bait, Black Island, Hardy and Hook reefs. This damage was most likely due to heavy wave action during the cyclone's initial phase when it was farther away but stronger, stationary and larger in extent.

Offshore from Mackay and Gladstone, questionnaire respondents visited three reefs after the cyclone (Figure A3.8, panel 3), of which damage was reported for Lady Musgrave Island only. The island is far more exposed to ocean swell than the other sites and damage was most likely sustained from heavy seas during the first phase of the cyclone. In contrast, Eton, and particularly Emporer, Reefs would have been sheltered from these seas.

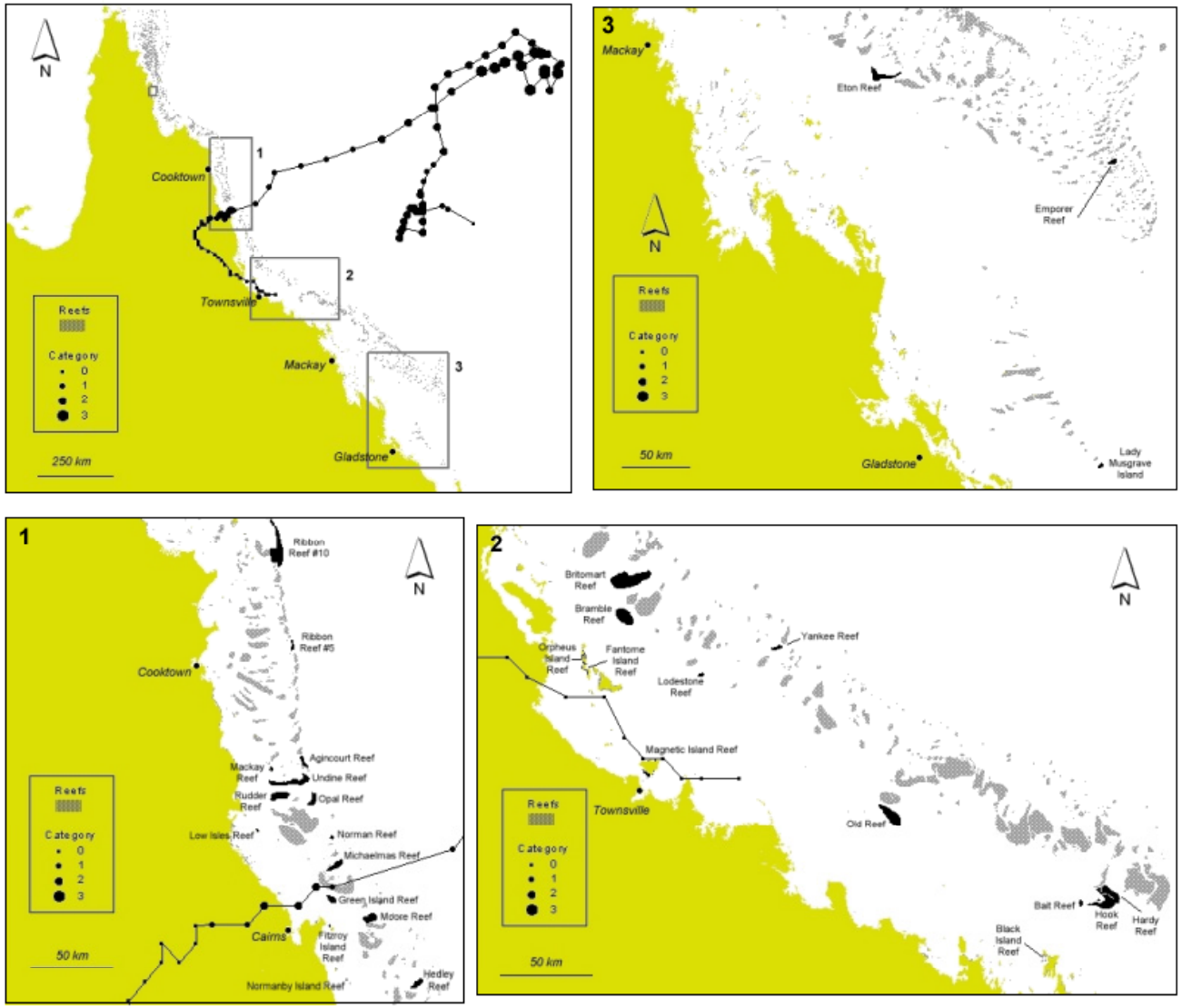



**Figure A3.8.** Reefs at which questionnaire respondents searched for wave damage from cyclone Justin (1997).

In summary, field surveys undertaken following cyclone Justin found severe, high-energy damage at only one site - the south face of Oublier Reef in the Whitsunday Islands region (Figure A3.7). The position of this site in relation to the cyclone path was inconsistent with damage having been caused by waves generated by a local rotating wind field. Instead, the damage probably resulted from confused seas generated within the reef complex by the cyclone when it was located hundreds of kilometres away in the Coral Sea. Results from the questionnaires suggest that low severity damage extended across much of the GBR, and some high-energy damage occurred close to the cyclone path as it crossed the coast at Cairns. There was no evidence of damage from the cyclone when it re-entered the GBR lagoon just north of Townsville as a very weak category 1 storm.

## CYCLONE ALTHEA

Cyclone Althea crossed the GBR from 23-24 December 1971 (Figure A3.9). Unusually for the GBR, Althea remained severe (category 3) until after crossing the coast at Townsville. The size of the cyclone is unknown, but widespread location of recorded damaged sites suggests that it may have been large.

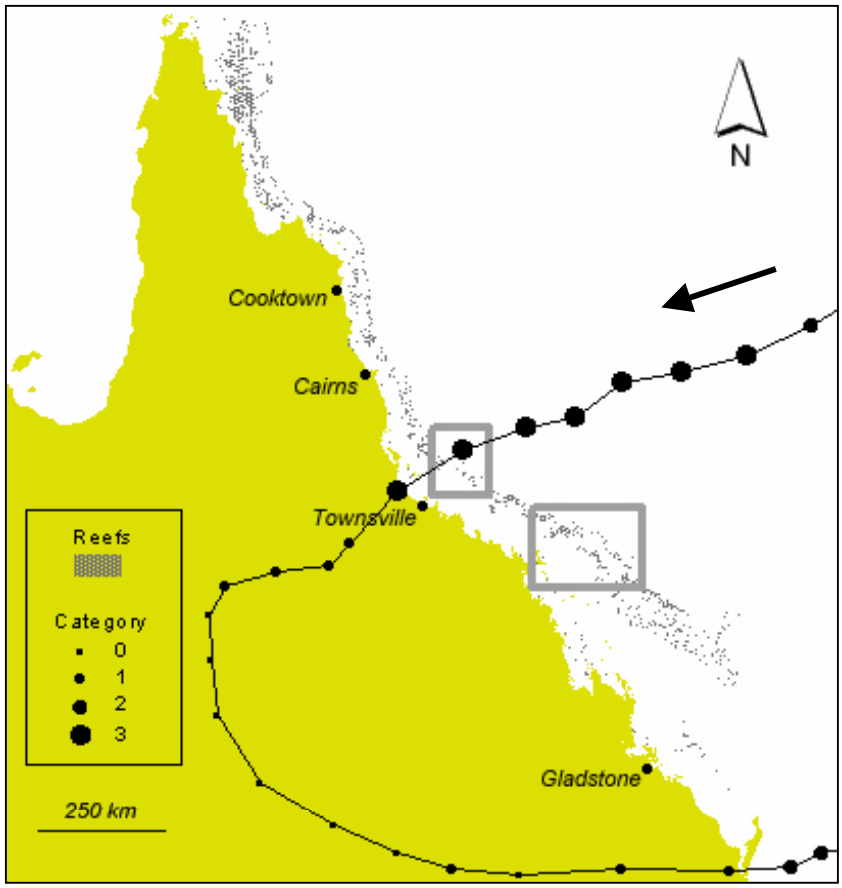



**Figure A3.9:** Track of cyclone Althea (December 1971). Reef sites for which cyclone wave damage was noted during crown-of-thorns starfish field surveys are located within the thick gray boxes.

This damage was likely to be high-energy in nature because it was obvious to workers who were not searching for it, some months after it had occurred. These sites extend from one reef located about 10 km north of the cyclone path to two clusters of reefs located 200-300 km south of the path (Figure A3.10).

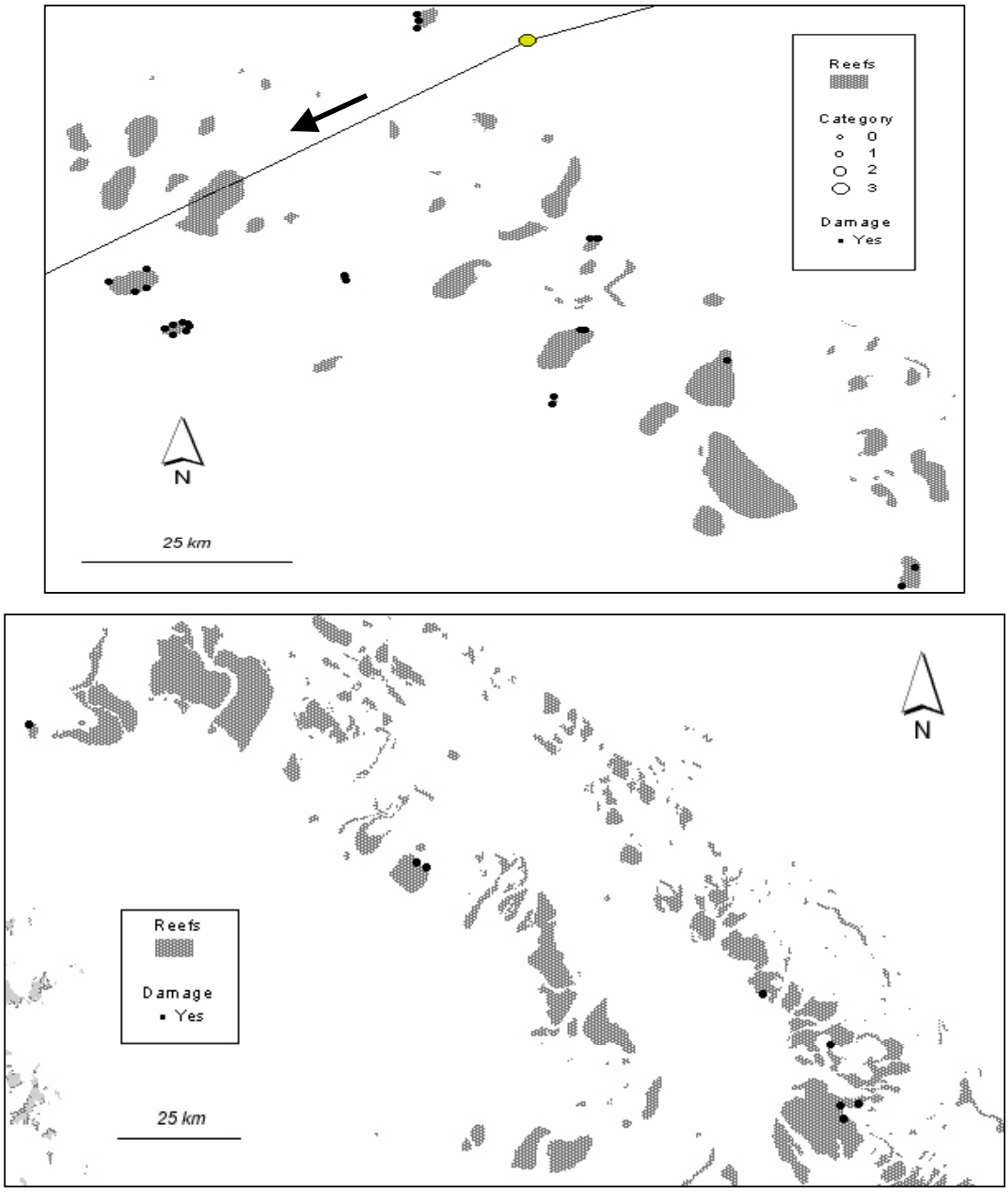



**Figure A3.10:** Reefs at which damage from cyclone Althea (1971) were incidentally noted during crown-of-thorns starfish surveys, as reported in COTSBASE 1.0 (Hartcher 2001). The cyclone moved in the direction of the arrow.

Since these observations were not part of a cyclone damage survey, all observations indicate some level of impact (Table A3.1).

**Table A3.1:** Records of probable wave damage following cyclone Althea (1971) noted during crown-of-thorns starfish surveys reported in COTSBASE 1.0 (Hartcher 2001).

| Reef Name | # Sites | Damage | |
|---|---|---|---|
| | | *Yes* | *No* |
| Bait Reef | 1 | x | |
| Bowden Reef | 2 | x | |
| Centipede Reef | 3 | x | |
| Gilbey Reef | 1 | x | |
| Helix Reef | 2 | x | |
| John Brewer Reef | 4 | x | |
| Knife Reef | 3 | x | |
| Lodestone Reef | 7 | x | |
| Lynch's Reef | 1 | x | |
| Myrmidon Reef | 3 | x | |
| Old Reef | 1 | x | |
| Square Reef | 2 | x | |
| Wheeler Reef | 2 | x | |

In addition, observations of storm surge and other surface impacts during the cyclone (Hopley 1972) suggest the likelihood of significant damage to reef sites located offshore from Townsville and, to a lesser degree, offshore from Gladstone.

## CYCLONE CELESTE

Cyclone Celeste crossed the GBR from 26 to 29 January 1996 (Figure A3.11).

Celeste actually formed within the GBR, which is rare.

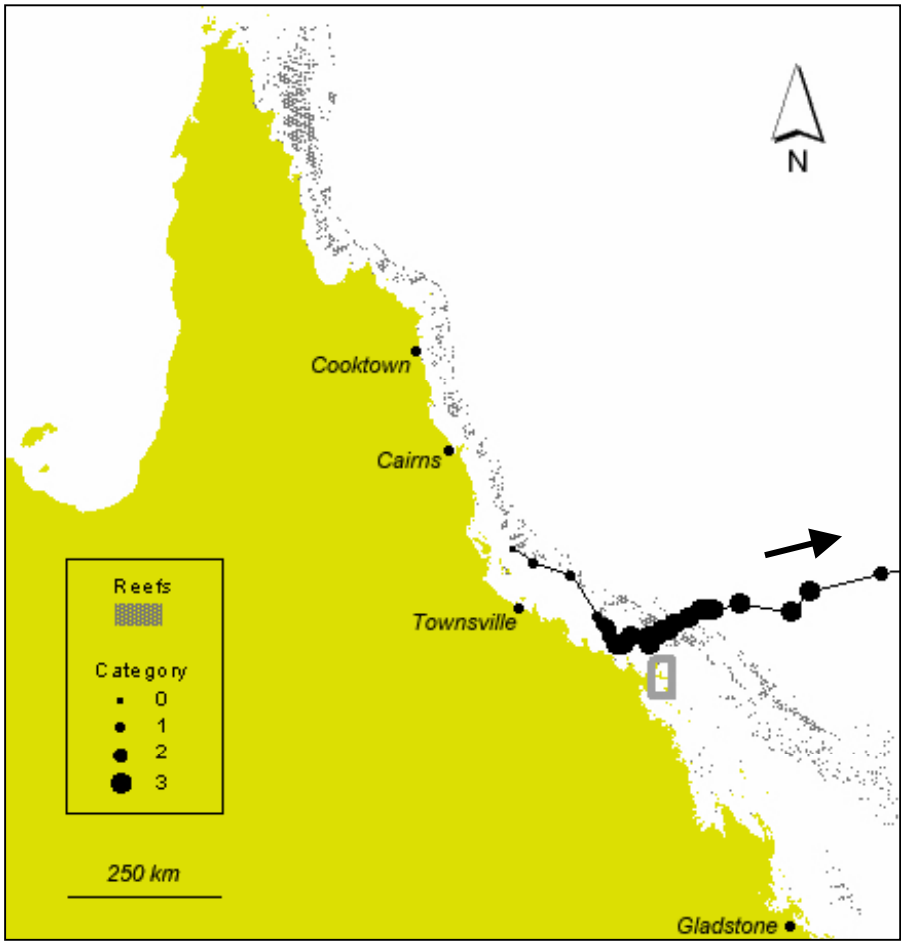



**Figure A3.11:** Track of cyclone Celeste. Reef sites surveyed by Malcolm et al (1996) are located within the thick gray box. The cyclone moved in the direction of the arrow.

Celeste was also small in size, with a radius to gale force winds of only ~50 km when at maximum intensity (Callaghan 1997). As the cyclone intensified, it passed within 24 km of Bowen before recurving to head quickly eastward through the GBR. Celeste passed just north of the Whitsunday Islands while reaching peak intensity (category 3), but weakened quickly afterwards. Cyclone Celeste tracked close to Oublier Reef while at high intensity (category 3). This raises the question of whether the extreme damage observed there could have been caused by cyclone Celeste rather than Justin. While a maximum wave height of 6.2 metres was recorded near Hayman

Island (with the average top 1/3 waves at ~ 3 m), these high-energy conditions dissipated after only about 3 hours (Malcolm et al 1996).

Malcolm et al (1996) surveyed 7 sites on 5 reefs in the Whitsunday Islands region of the GBR (Figure A3.12) following the cyclone. Although the cyclone passed close to these sites (within ~50 km) while at maximum intensity (category 3), only scattered low-energy damage was recorded. This is likely due to the unusually high speed with which the cyclone passed through the area, which was insufficient to build large waves.

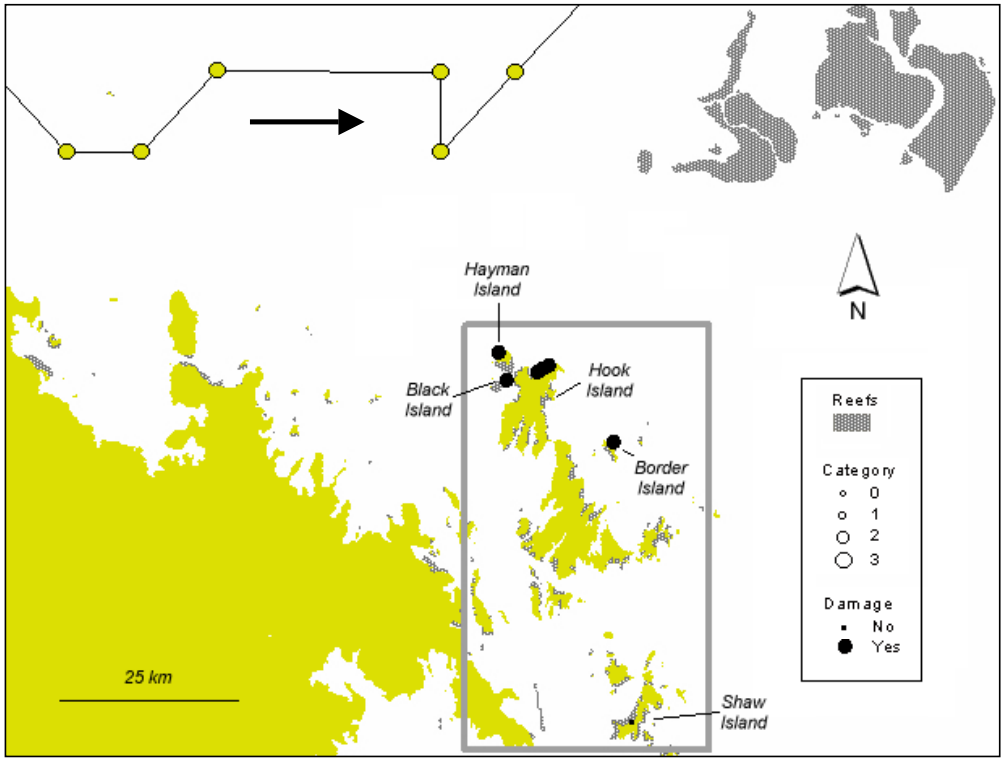



**Figure A3.12:** Reef sites surveyed following cyclone Celeste by Malcolm et al 1996. The cyclone moved in the direction of the arrow.

Patchy, low-energy damage (mostly widespread broken corals) was observed at 6 of the 7 sites surveyed (Table A3.2). No evidence was found of high-energy damage despite the severity of the cyclone.

**Table A3.2:** Field observations of wave damage following cyclone Celeste by Malcolm et al (1996).

| Site # | Name | Damage | |
|---|---|---|---|
| | | *Yes* | *No* |
| 1 | Hook Island Reef | x | |
| 2 | Hook Island Reef | x | |
| 3 | Hook Island Reef | x | |
| 4 | Hayman Island Reef | x | |
| 5 | Border Island Reef | x | |
| 6 | Black Island Reef | x | |
| 7 | Shaw Island Reef | | x |

Again, this is likely due the lack of time for waves to build and the unusually small extent of the cyclone's high wind region.

# APPENDIX 4: Wind model validation data

Additional weather station data is provided below for cyclones Justin and Celeste, and should be examined in conjunction with Chapter 4.

## *A4.1 Cyclone Justin*

HOLMES REEF

Although the model over predicted wind speeds between about 175 and 225 hours, in general the model performed reasonably well at Holmes Reef (Figure A4.1). This may be partly due to the fact that cyclone Justin passed relatively close to the station (within about 60 km). Directions are also modelled fairly well (though mainly more southerly than the observations) until the cyclone crossed the coast at Cairns. There appears to be no clear advantage to incorporating the secondary vortex into the simulation.

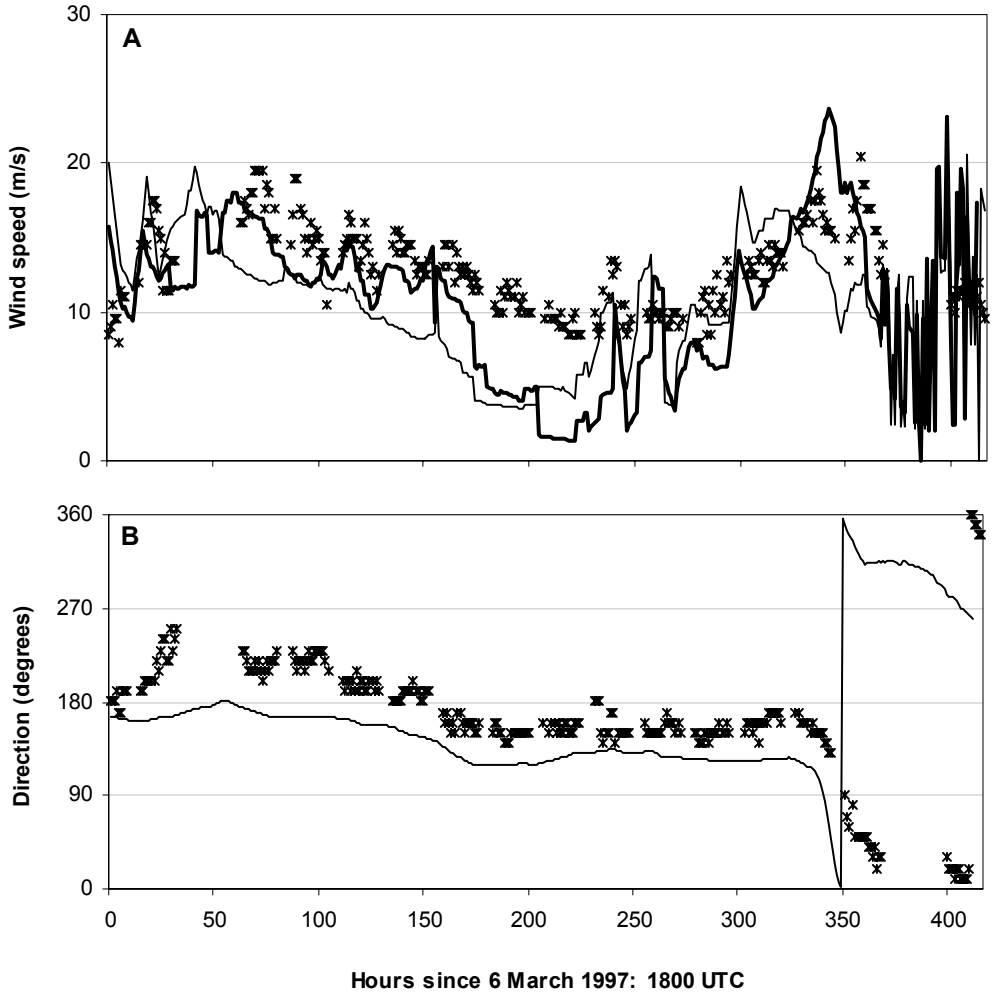



**Figure A4.1:** 10 metre surface wind speeds (A) and directions (B) during Cyclone Justin (March 1997) at Holmes Reef (latitude: 16.47$^0$S, longitude: 148.87$^0$E). Asterisks show measurements taken by the Bureau of Meteorology weather station (altitude: 8.0 metres). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

## GREEN ISLAND

The worst model fit for both wind speeds and directions at Green Island was during the early phase of the cyclone when observations were highly variable (Figure A4.2). After about 100 hours, directions were modelled reasonably well, though generally more easterly than the observations. Wind speeds were modelled most accurately

after about 250 hours, when the cyclone began its approach towards Cairns (and passed closer to the station). Again, there seems to be no clear advantage to incorporating the secondary vortex into the simulation.

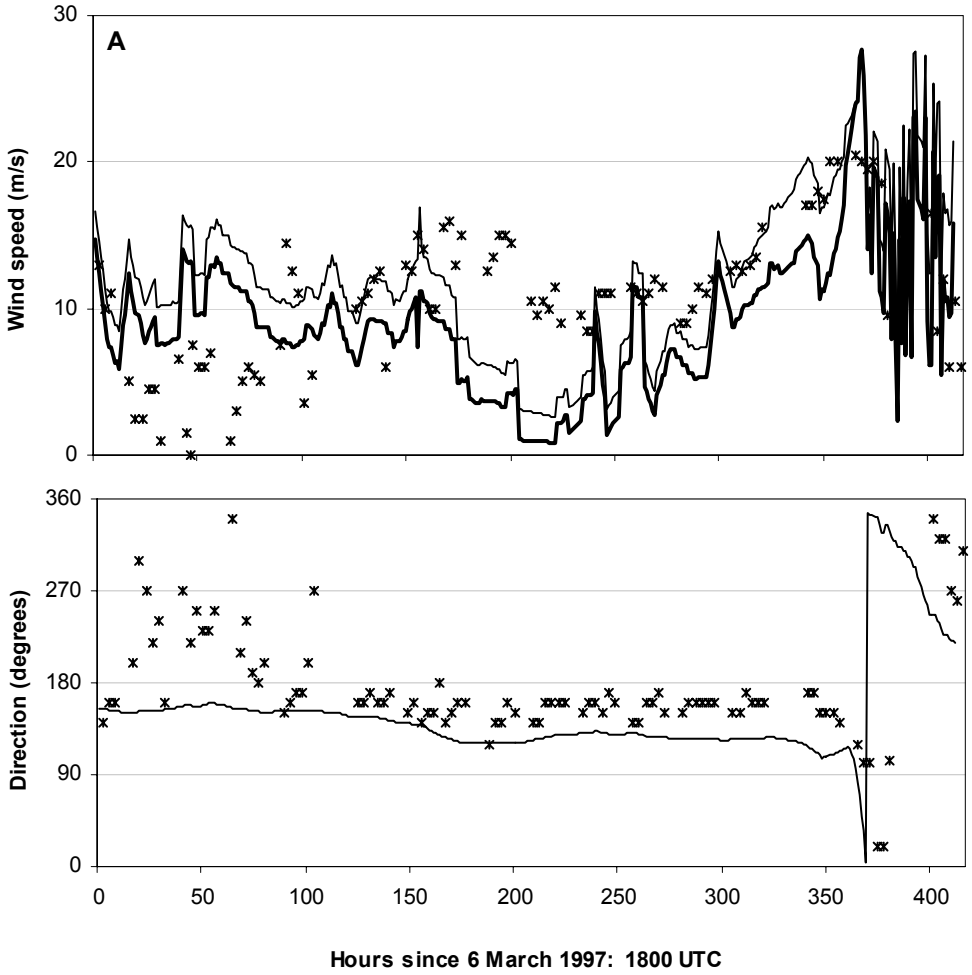



**Figure A4.2:** 10 metre surface wind speeds (A) and directions (B) during Cyclone Justin (March 1997) at Green Island (latitude: 16.76$^0$S, longitude: 145.97$^0$E). Asterisks show measurements taken by the Bureau of Meteorology weather station (altitude: 3.0 metres). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

HOOK REEF

The fit between modelled and observed wind speeds at Hook Reef was best in the early and late stages of the cyclone (Figure A4.3). Modelled wind directions followed

the same trend as the observations, though always more easterly. There was no advantage to incorporating the secondary vortex into the simulation.

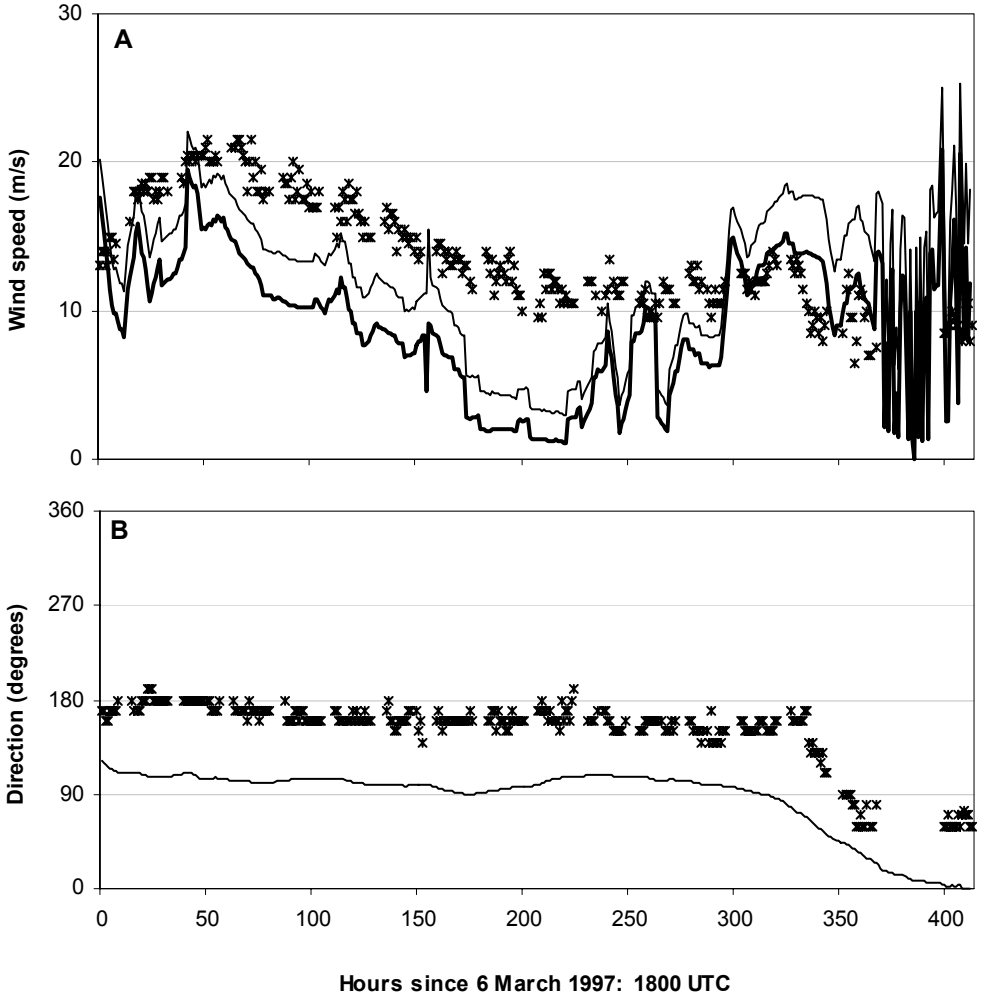



**Figure A4.3.** 10 metre surface wind speeds (A) and directions (B) during Cyclone Justin (March 1997) at Hook Reef (latitude: 19.74$^0$S, longitude: 149.17$^0$E). Asterisks show measurements taken by the Bureau of Meteorology weather station (altitude: 2.6 metres). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

## HAMILTON ISLAND

Modelled and observed wind speeds at Hamilton Island diverged the most from about 175 to 225 hours (Figure A4.4). Speeds were under-predicted until about 300 hours,

after which they were over-predicted. Directions matched reasonably well, though the predictions were always more northerly than the observations. Reefs located in the vicinity of Hamilton Island were most likely affected by cyclone waves during the early phase of the storm when wind speeds were over-predicted by about 5 $m.s^{-1}$. Again, there seems to be little advantage to incorporating the secondary vortex into the simulation.

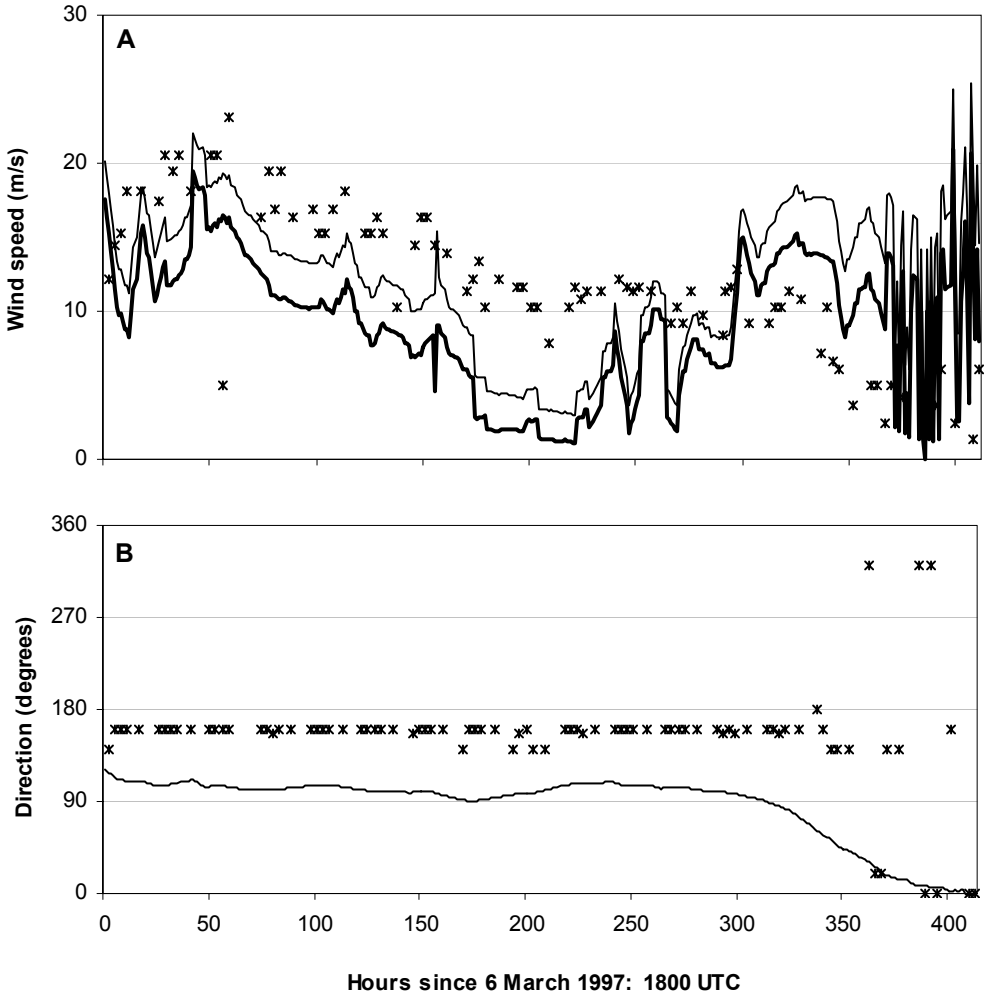



**Figure A4.4:** 10 metre surface wind speeds (A) and directions (B) during Cyclone Justin (March 1997) at the Hamilton Island airport (latitude: $20.35^0$S, longitude: $148.95^0$E). Asterisks show measurements taken by the Bureau of Meteorology weather station (altitude: 22.6 metres). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

FREDERICK REEF

Observed and modelled wind speeds at Frederick Reef matched poorly except for a brief period from about 250 to 300 hours (Figure A4.5).

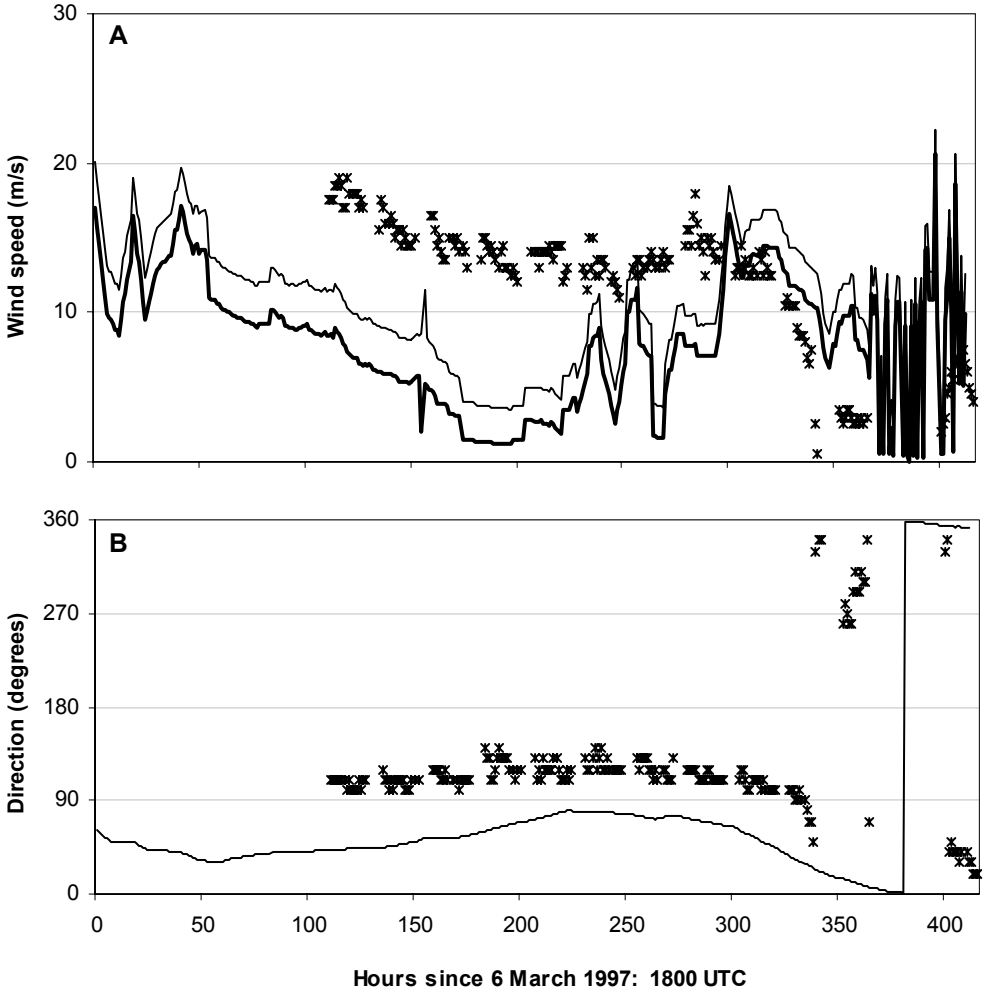



**Figure A4.5.** 10 metre surface wind speeds (A) and directions (B) during Cyclone Justin (March 1997) at Frederick Reef (latitude: 20.94$^0$S, longitude: 154.4$^0$E). Asterisks show measurements taken by the Bureau of Meteorology weather station (altitude: 12.8 metres). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

Neither the primary nor the primary + secondary vortices performed well, as the model greatly under predicted actual wind speeds. This may be due to synoptic winds generated from the pressure gradient between the cyclone and the larger environment,

which are known to be stronger south of the cyclone (McConochie et al 1999). Also, the cyclone was about 450 km away from the weather station at its closest approach. Model predictions of wind directions were more successful, generally falling within 45 degrees (though always more northerly) of the observed directions until the cyclone crossed land at Cairns.

## GANNET CAY REEF

At Gannet Cay Reef, wind directions were generally well predicted (Figure A4.6), though always more northerly than the observations. Wind speeds were consistently over predicted until about 300 hours, when they were slightly under predicted. The best fit for wind speed was the early phase of the storm. Incorporating the secondary vortex appeared to offer little advantage. However, the cyclone never passed within 500 metres of Gannet Cay Reef, which may explain the poor performance of the model.

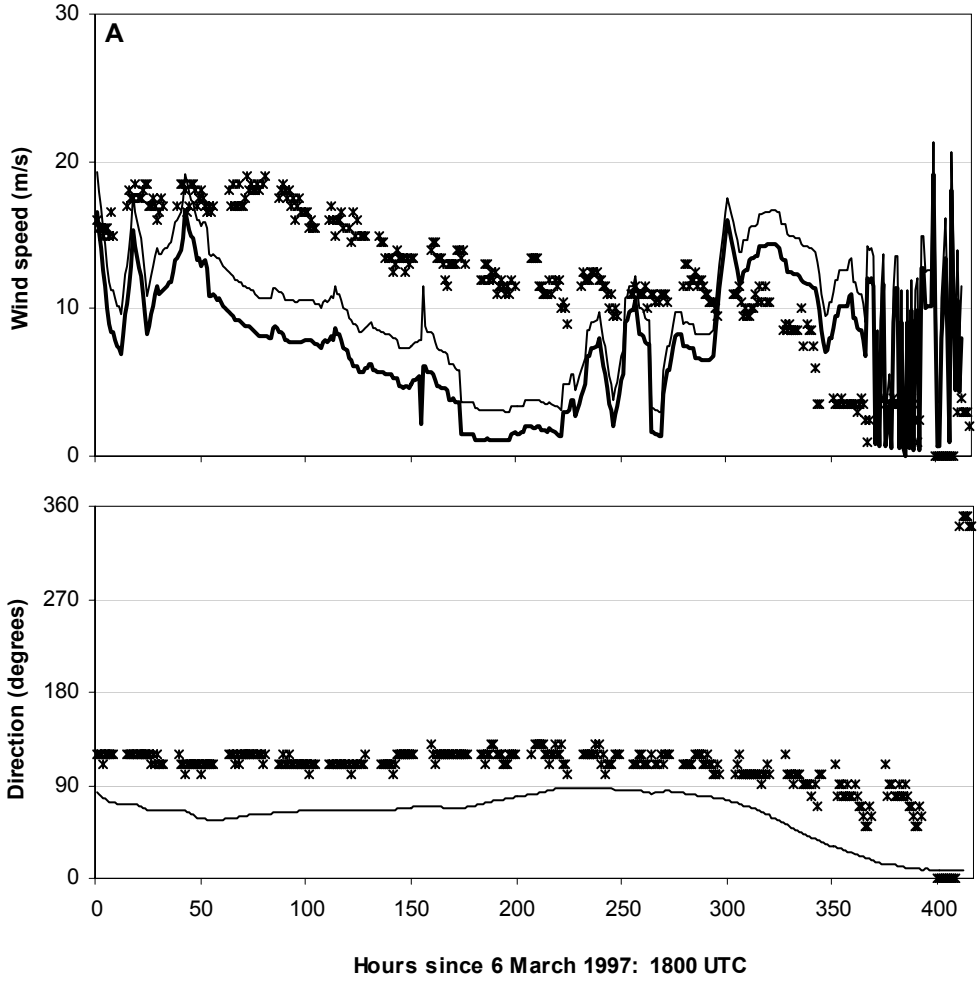



**Figure A4.6.** 10 metre surface wind speeds (A) and directions (B) during Cyclone Justin (March 1997) at Gannet Cay (latitude: 21.98$^0$S, longitude: 152.47$^0$E). Asterisks show measurements taken by the Bureau of Meteorology weather station (altitude: 2.3 metres). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

## *A4.2 Cyclone Celeste*

### GREEN ISLAND

Wind speeds recorded at Green Island were generally lower than those predicted by the model (Figure A4.7). Because of this, the primary vortex alone performed better. The compact nature of cyclone Celeste and its fast transit through the GBR may partially explain this. Also, the closest approach of the cyclone to the island was

nearly 175 km away, increasing uncertainty in the model results. Wind direction was modelled very poorly except at the very beginning of the cyclone.

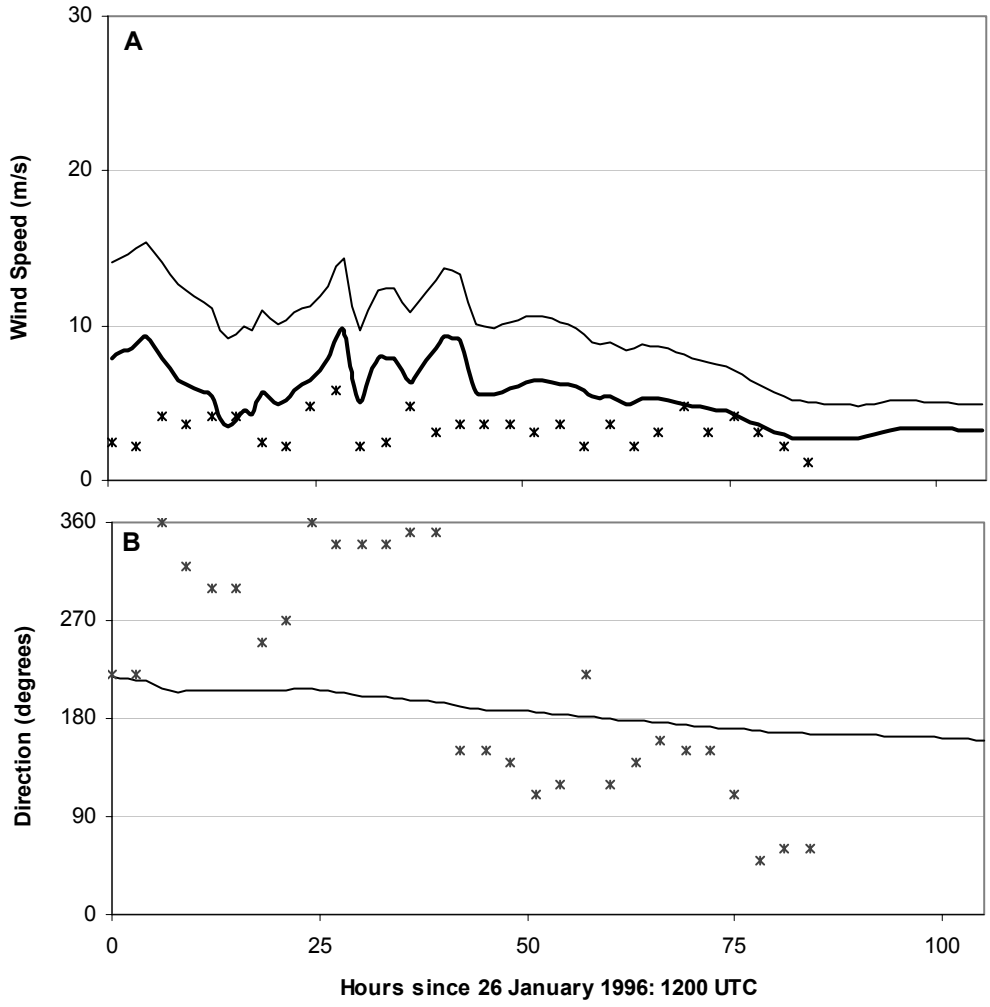



**Figure A4.7:** 10 metre surface wind speeds (A) and directions (B) during Cyclone Celeste (1996) at Green Island (latitude: $16.76^0$S, longitude: $145.97^0$E). Asterisks show measurements taken by the Bureau of Meteorology automatic weather station (altitude = 3.0 m). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

## HAMILTON ISLAND

Of all the stations available during cyclone Celeste, Hamilton Island was located closest to the path (within 30 km), where the model results are generally likely to be most accurate. However, the major peak in wind speeds predicted by the model was

not reflected in the observed data (Figure A4.8). This could be due to the lack of an accurate radius of maximum wind measurement - a value of 30 km had to be used in the absence of evidence even though it is likely that the eye width was less than that. This means that the island was predicted in the model to lie along the eye wall (where winds should be highest), when this may not have been the case. Further, like Fitzroy Island, Hamilton contains complex topography that may have reduced wind speeds. There was no advantage in using the secondary vortex for this simulation. For the most part, the model estimated actual wind directions poorly.

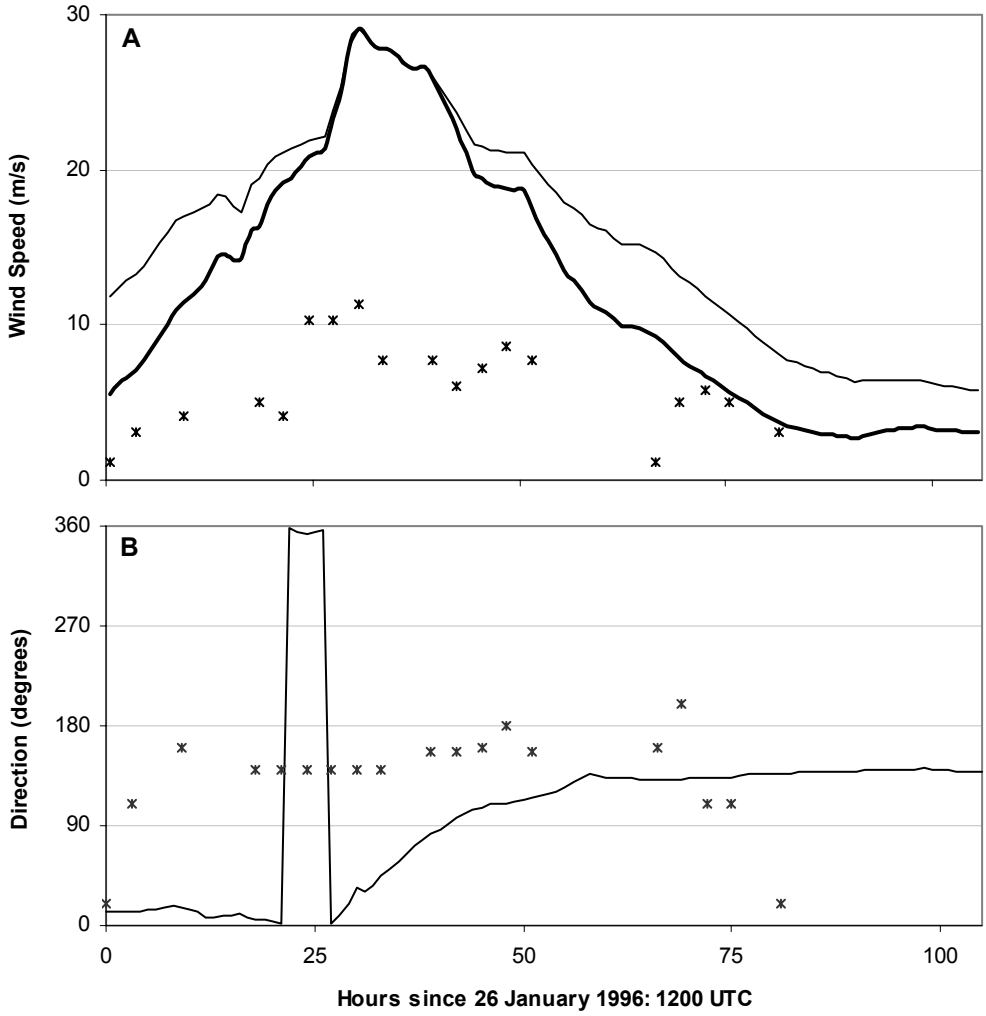



**Figure A4.8.** 10 metre surface wind speeds (A) and directions (B) during Cyclone Celeste (1996) at the Hamilton Island airport (latitude: $20.35^0$S, longitude: $148.95^0$E). Asterisks show measurements taken by the Bureau of Meteorology automatic weather station (altitude = 22.6 m). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

## GANNET CAY REEF

Similar patterns were evident at Gannet Cay Reef (Figure A4.9), though wind speeds were generally lower due to its location further south of the cyclone than Creal Reef. For the most part, wind speeds fit the observations more closely than for Creal, though the directions again did not track the periodic oscillations in wind speed apparent in the observed data. Again, the primary vortex alone provided a better fit.

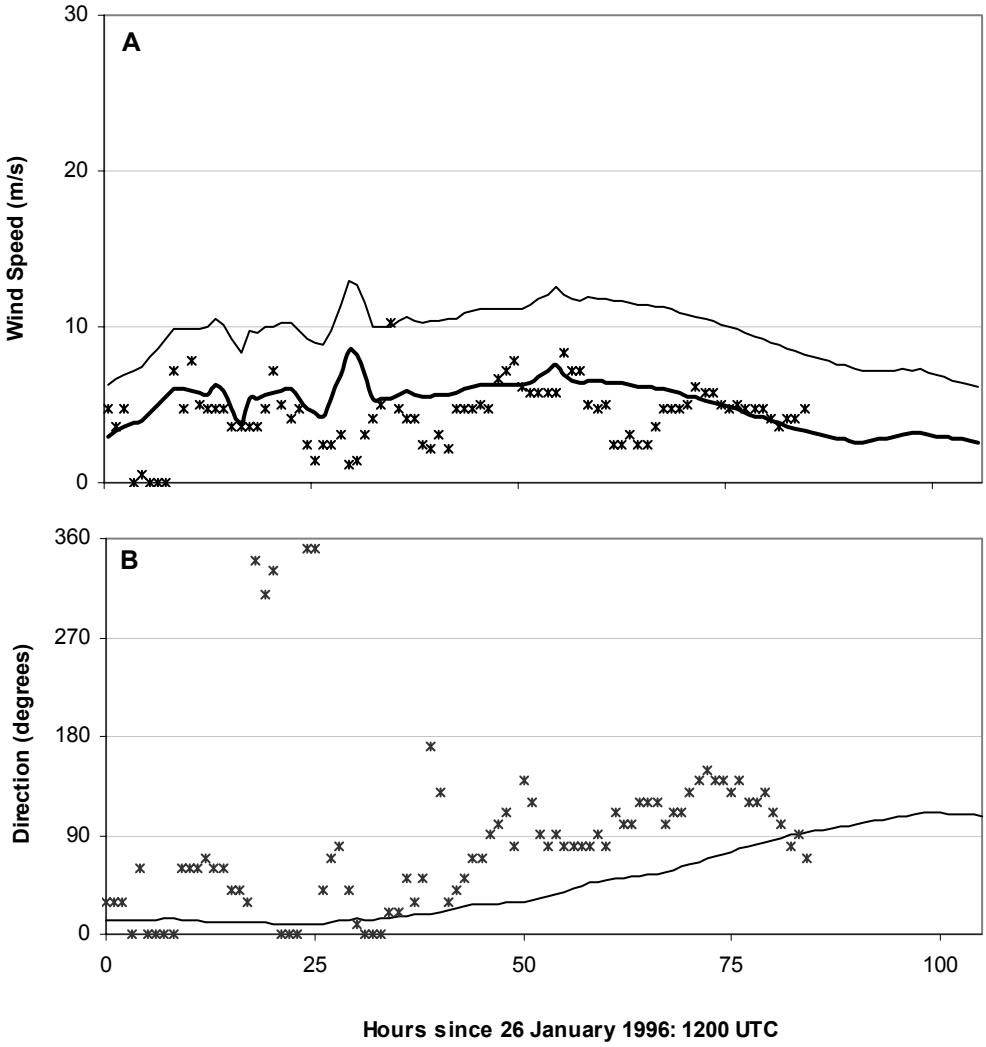
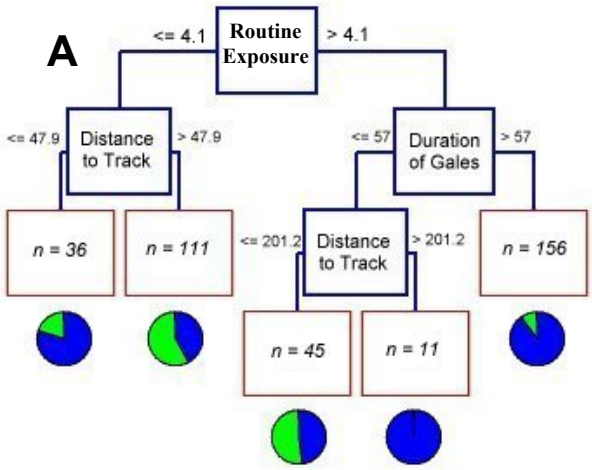



**Figure A4.9:** 10 metre surface wind speeds (A) and directions (B) during Cyclone Celeste (1996) at Gannet Cay Reef (latitude: $21.98^0$S, longitude: $152.47^0$E). Asterisks show measurements taken by the Bureau of Meteorology automatic weather station (altitude = 2.3 m). The lines in (A) show winds predicted from the primary (thick) and primary + secondary (thin) vortices.

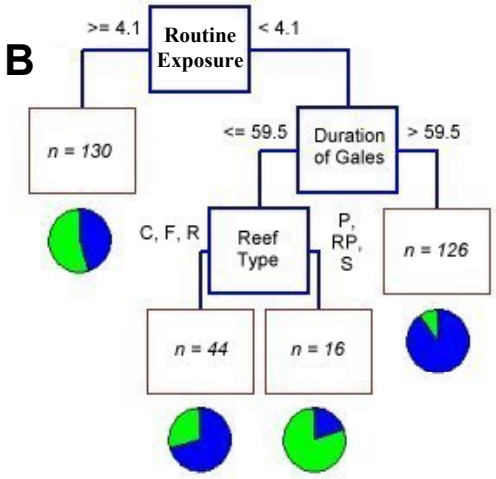
# APPENDIX 5: Additional classification and regression trees

Classification and regression trees were fitted for combinations of cyclones Ivor, Joy, Justin, Althea and Celeste to attempt to explain patterns across fourteen types and severities of damage: damage of any type or severity, severe damage of any type, maximum damage of any type, total damage of all types, total low-energy damage, total high-energy damage, breakage, debris scars, dislodgement of massive colonies, exfoliation, fallen slabs, sand movement, soft coral stripping and trenching. Trees that were unsuitable for prediction due to poor classification accuracy, indistinct nodes (limited ability to distinguish between presence and absence), and/or lack of ecological relevance are presented below. The remaining trees are discussed in Chapter 6.

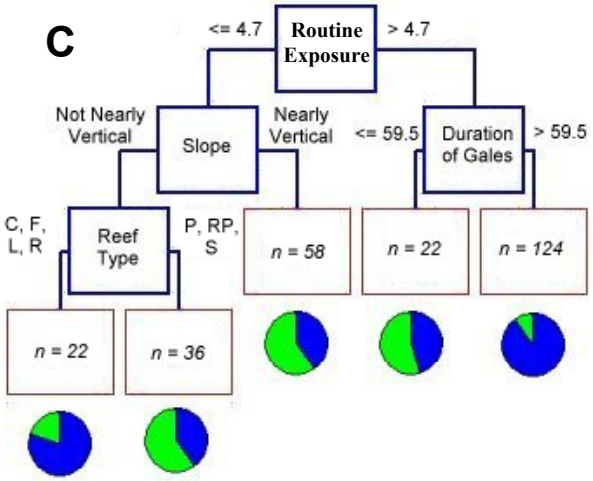
## *A5.1 Damage of any type or severity*




10 fold cross validated classification accuracy: Yes = 66.0% No = 75.5%




10 fold cross validated classification accuracy:
Yes = 60.0% No = 77.4%




10 fold cross validation classification accuracy: Yes = 69.1 No = 71.43

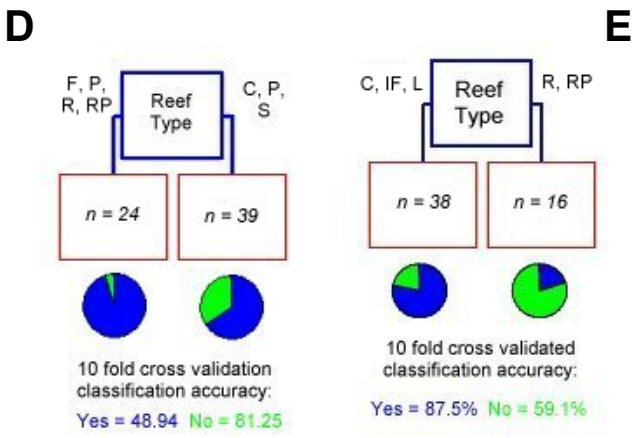



**Figure A5-1.** Classification tree fitted for the presence versus absence of any type or severity of damage for cyclones: A - Ivor, Joy, Justin, Althea and Celeste, and B – Ivor, Joy and Justin, C – Ivor and Joy, D – Ivor, and E – Justin. The relative purity of the terminal nodes (as shown by the pie diagrams, where black = damaged and grey = not damaged) and the classification accuracy indicate the success of the tree.

## *A5.2 Severe damage of any type*

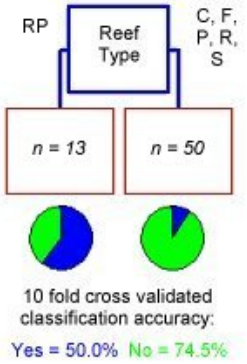



**Figure A5-2.** Classification tree fitted for severe damage of any type for cyclone Ivor. The relative purity of the terminal nodes (as shown by the pie diagrams, where black = damaged and grey = not damaged) and the classification accuracy indicate the success of the tree. Reef type code C = Crescentic, CF = Coastal Fringing, F = Fringing, IF = Incipient Fringing, L = Lagoonal, P = Planar, R = Ribbon, RP = Reef Patches, and S = Submerged.

## *A5.3 Maximum damage of any type*

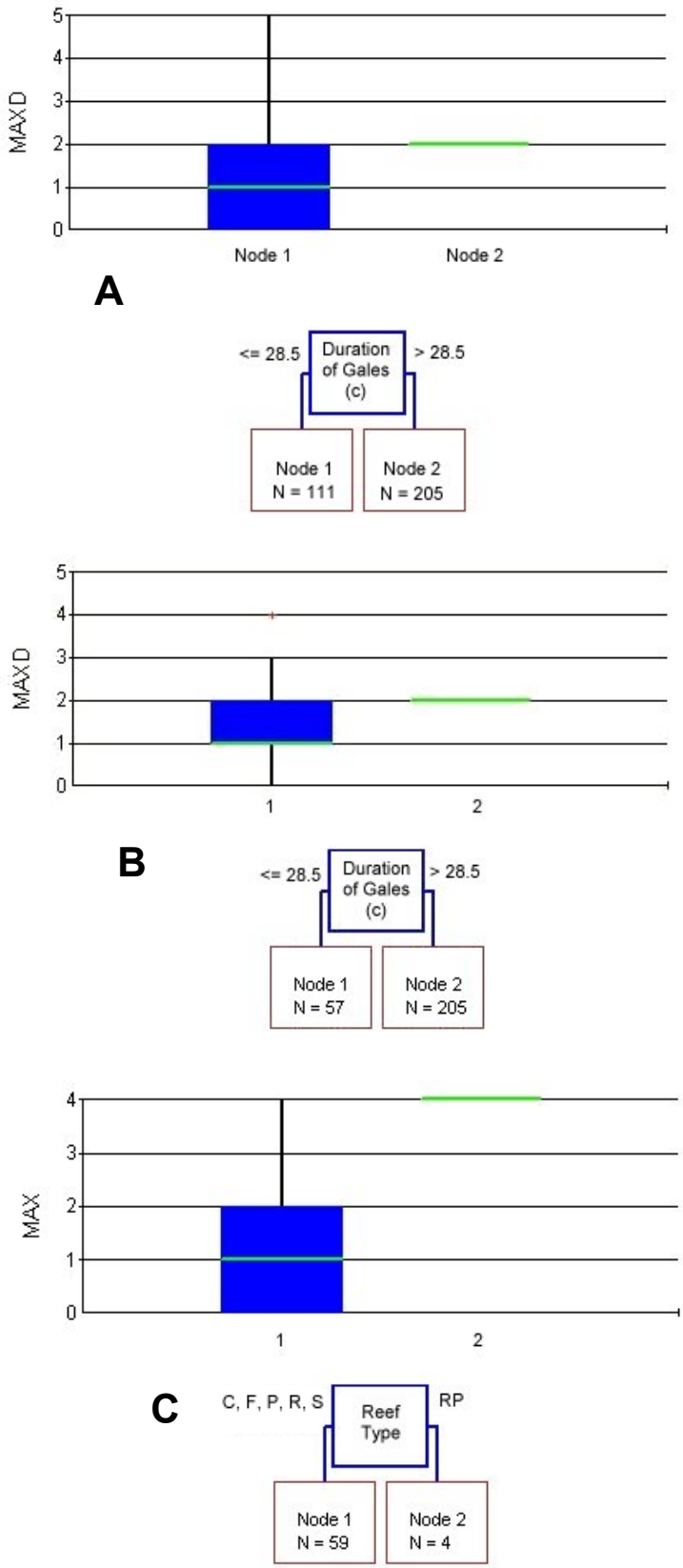



**Figure A5-3.** Regression tree fitted for maximum severity of damage of any type for cyclones: A - Ivor, Joy and Justin combined, B – Ivor and Joy combined, and C - Ivor. The box plot indicates the success of the tree. Reef

type code C = Crescentic, CF = Coastal Fringing, F = Fringing, IF = Incipient Fringing, L = Lagoonal, P = Planar, R = Ribbon, RP = Reef Patches, and S = Submerged.

## *A5.4 Total damage of all types*

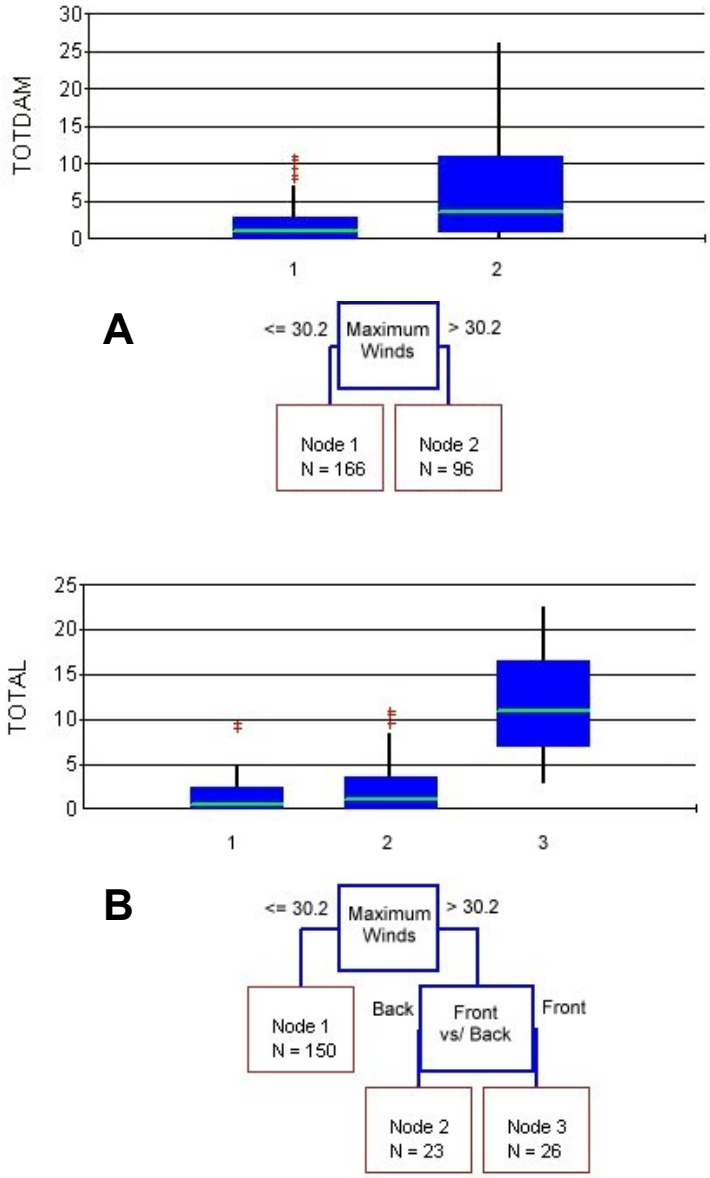
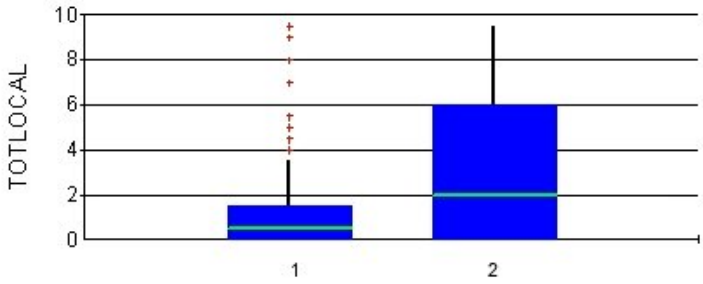
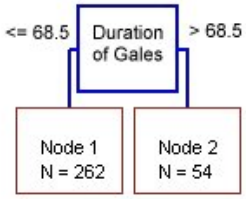


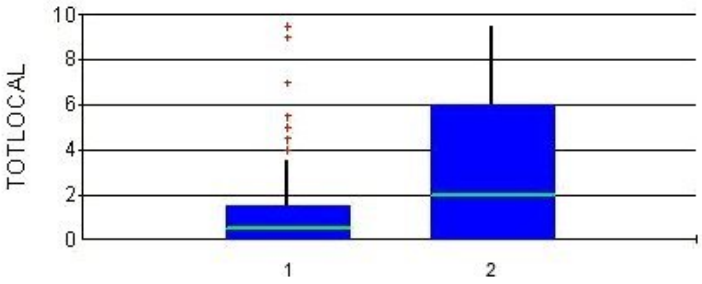

**Figure A5-4.** Regression tree fitted for the total severity of damage across all types for cyclones: A - Ivor and Joy combined and B - Joy. The box plot indicates the success of the tree.

## *A5.5 Total low energy damage*

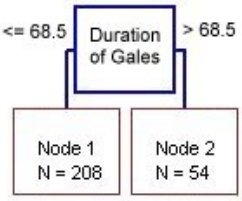



**A**




**B**



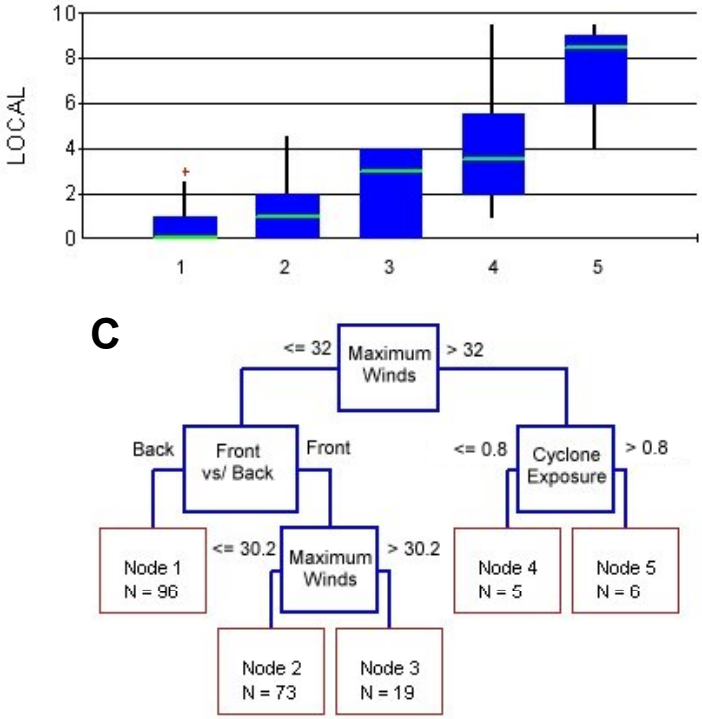
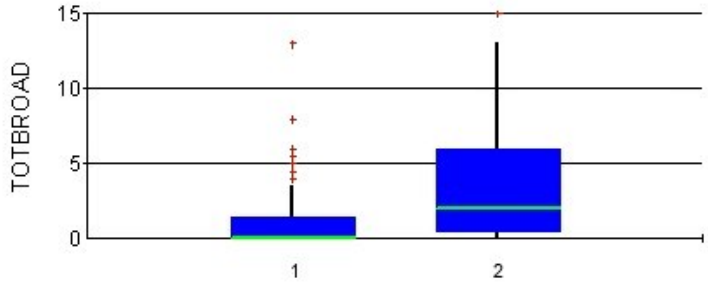
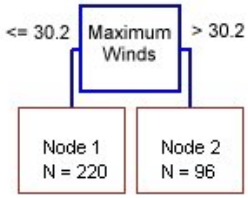


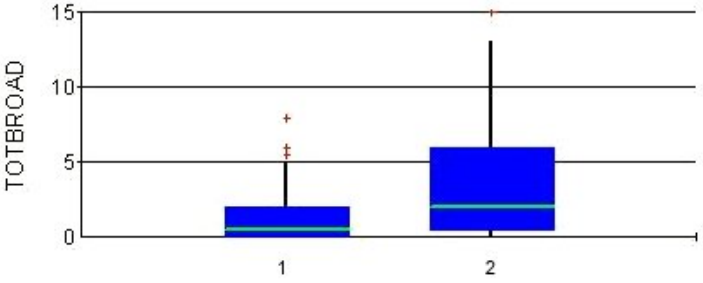

**Figure A5-5.** Regression tree fitted for the total severity of low energy damage across all types for cyclones: A - Ivor, Joy and Justin combined, B – Ivor and Joy combined, C - Joy. The box plot indicates the success of the tree.

## *A5.6 Total high energy damage*

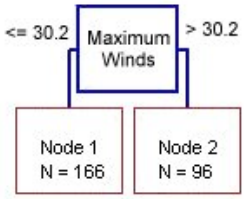



**A**




**B**



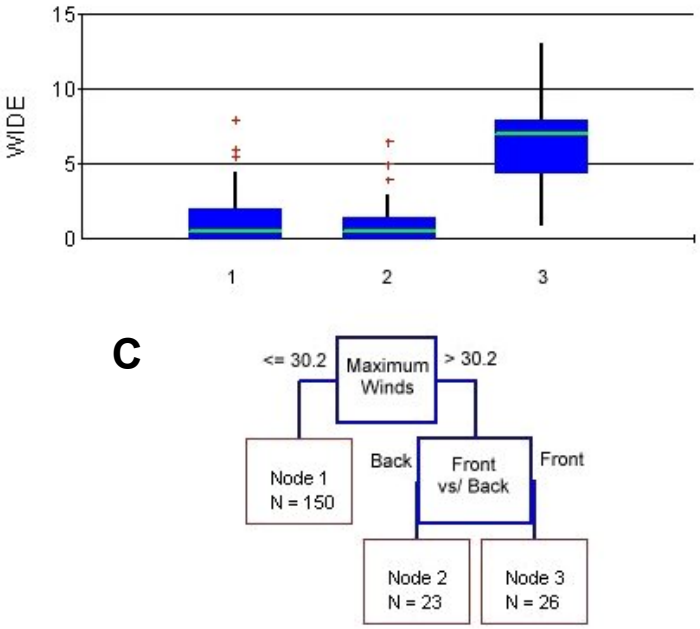



**Figure A5-6.** Regression tree fitted for the total severity of high energy damage across all types for cyclones: A - Ivor, Joy and Justin combined, B – Ivor and Joy, and C - Joy. The box plot indicates the success of the tree.

## *A5.7 Coral breakage*

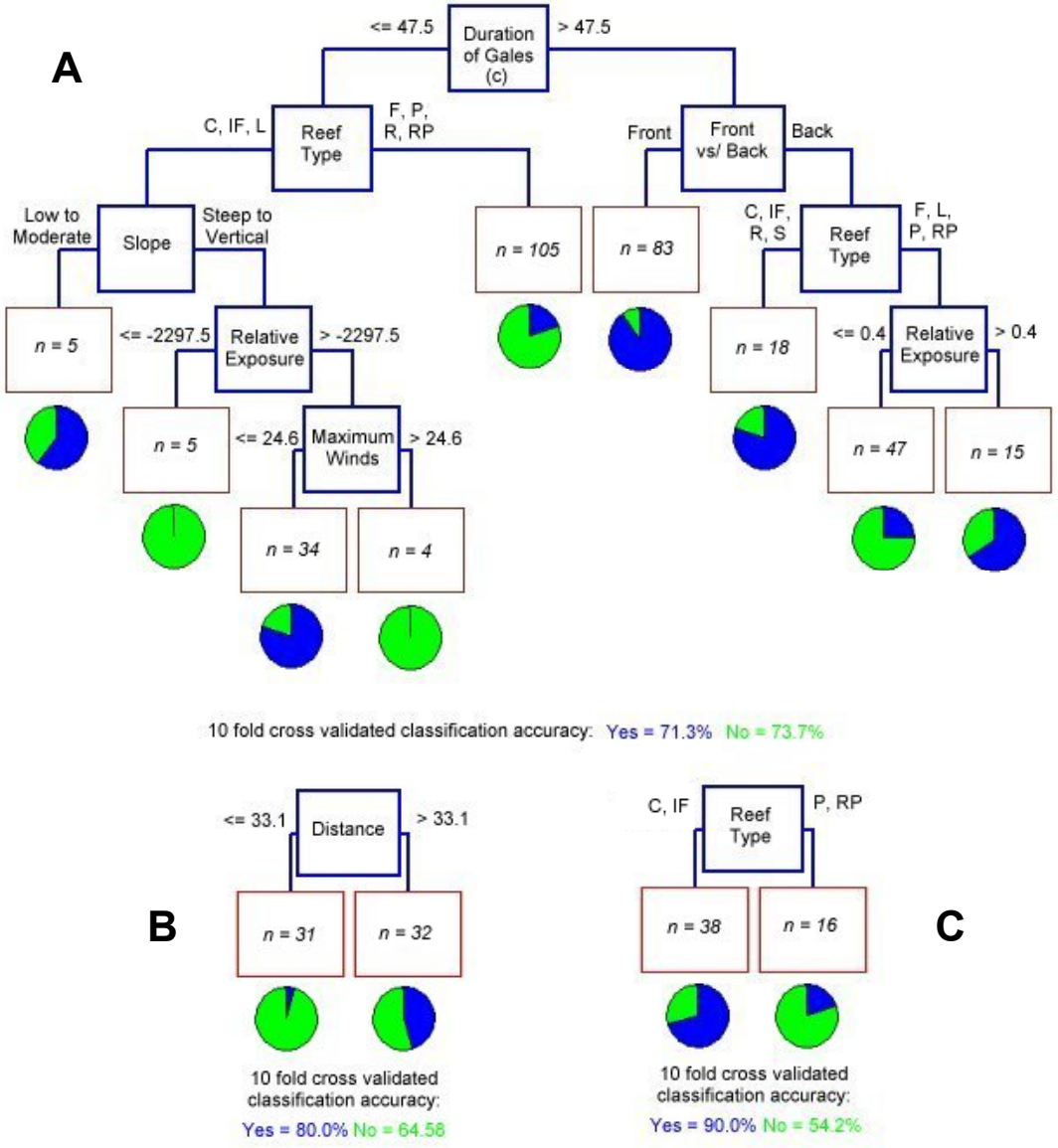



**Figure A5-7.** Classification tree fitted for the presence versus absence of coral breakage for cyclones: A - Ivor, Joy, and Justin, B – Ivor, and C - Justin. The relative purity of the terminal nodes and the classification accuracy indicate the success of the tree. Reef type code C = Crescentic, CF = Coastal Fringing, F = Fringing, IF = Incipient Fringing, L = Lagoonal, P = Planar, R = Ribbon, RP = Reef Patches, and S = Submerged.

## *A5.8 Debris scars*

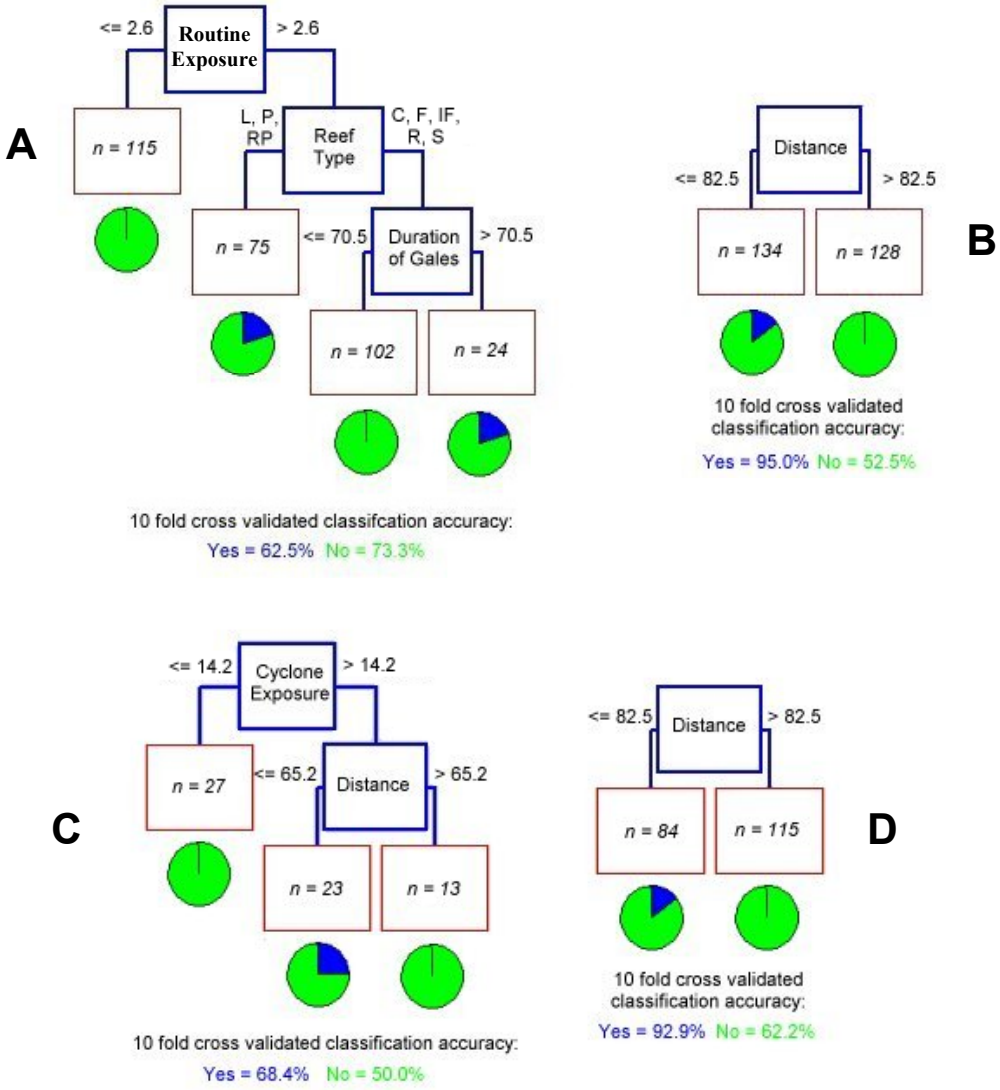
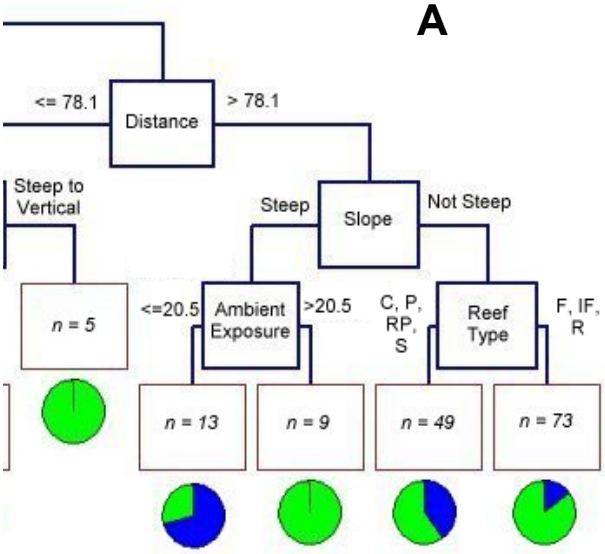



**Figure A5-8.** Classification tree fitted for the presence versus absence of debris scars for cyclones: A - Ivor, Joy, and Justin, B – Ivor and Joy, C – Ivor, and D - Joy. The relative purity of the terminal nodes and the classification accuracy indicate the success of the tree. Reef type code C = Crescentic, CF = Coastal Fringing, F = Fringing, IF = Incipient Fringing, L = Lagoonal, P = Planar, R = Ribbon, RP = Reef Patches, and S = Submerged.

nal classification and regression trees

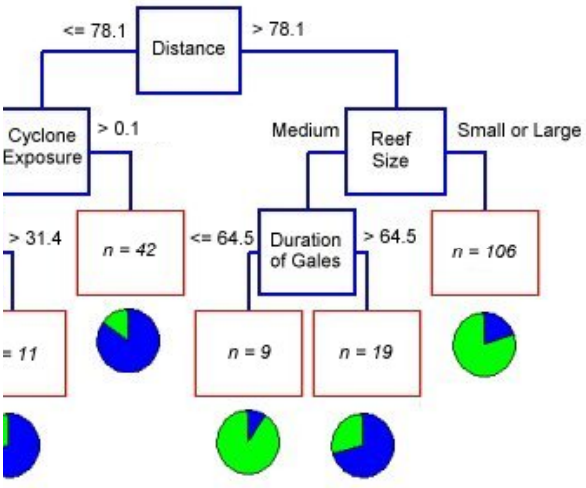
A




ross validated classification accuracy: Yes = 80.9% No = 66.5%

B

C




validated classification accuracy: Yes = 65.4% No = 70.3%

**Figure A5-9.** Classification tree fitted for the presence versus absence of dislodged massives for cyclones: A - Ivor, Joy, and Justin, B – Ivor, and C - Joy. The relative purity of the terminal nodes and the classification accuracy indicate the success of the tree. Reef type code C = Crescentic, CF = Coastal Fringing, F = Fringing, IF = Incipient Fringing, L = Lagoonal, P = Planar, R = Ribbon, RP = Reef Patches, and S = Submerged.

## *A5.10 Exfoliation*

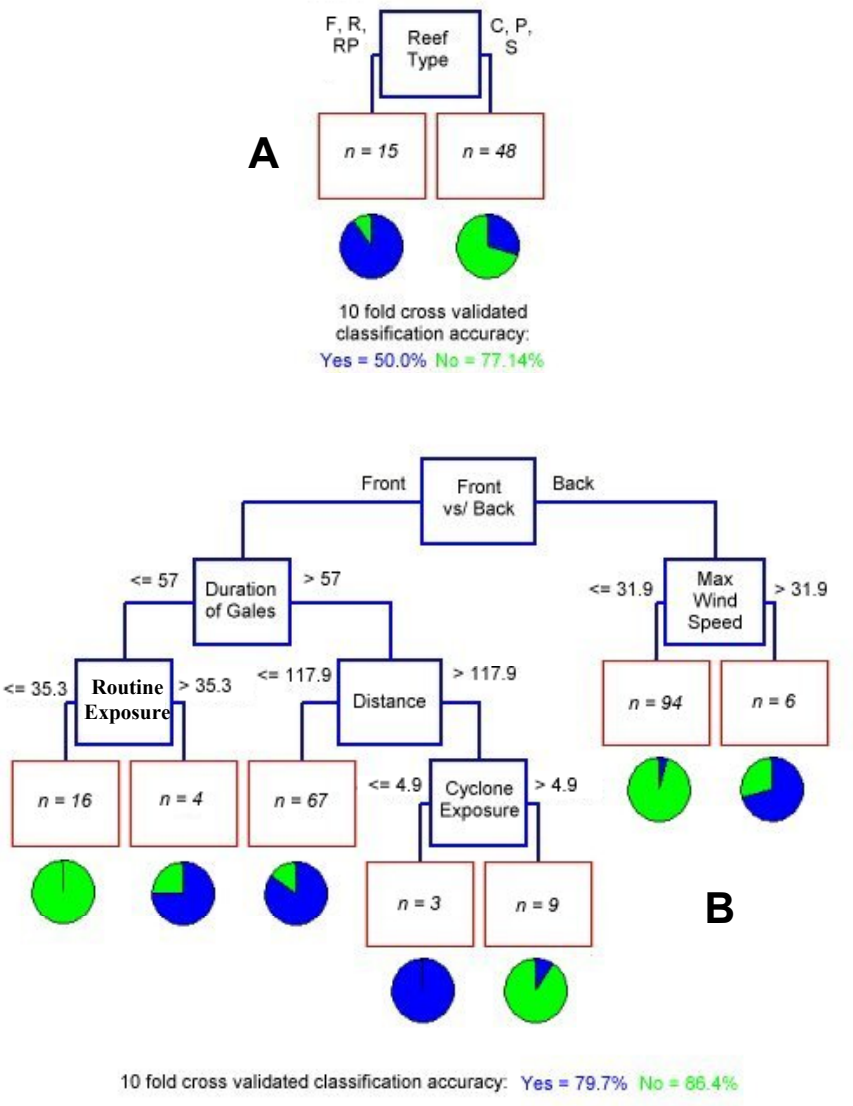



**Figure A5-10.** Classification tree fitted for the presence versus absence of exfoliation for cyclones: A - Ivor , and B - Joy. The relative purity of the terminal nodes and the classification accuracy indicate the success of the tree. Reef type code C = Crescentic, CF = Coastal Fringing, F = Fringing, IF = Incipient Fringing, L = Lagoonal, P = Planar, R = Ribbon, RP = Reef Patches, and S = Submerged.

## *A5.11 Fallen intact slabs*

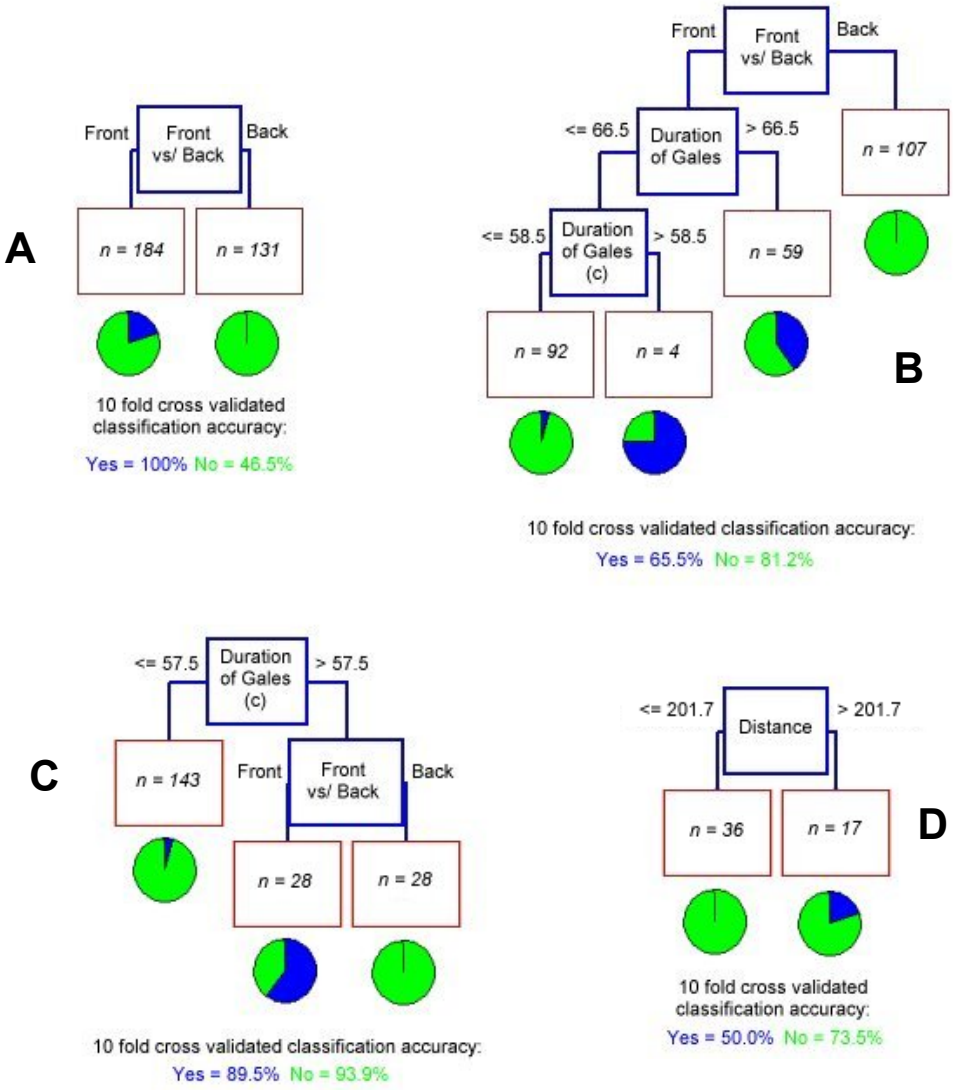



**Figure A5-11.** Classification tree fitted for the presence versus absence of fallen slabs for cyclones: A - Ivor, Joy, and Justin, B – Ivor and Joy, C – Joy, and D - Justin. The relative purity of the terminal nodes and the classification accuracy indicate the success of the tree.

## *A5.12 Stripped soft corals*

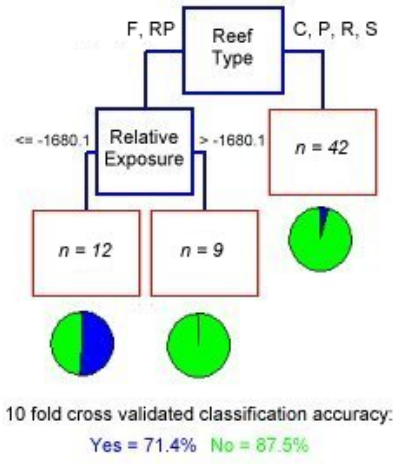



**Figure A5-12.** Classification tree fitted for the presence versus absence of stripped soft corals for cyclone Ivor. The relative purity of the terminal nodes and the classification accuracy indicate the success of the tree. Reef type code C = Crescentic, CF = Coastal Fringing, F = Fringing, IF = Incipient Fringing, L = Lagoonal, P = Planar, R = Ribbon, RP = Reef Patches, and S = Submerged.

## *A5.13 Trenching*

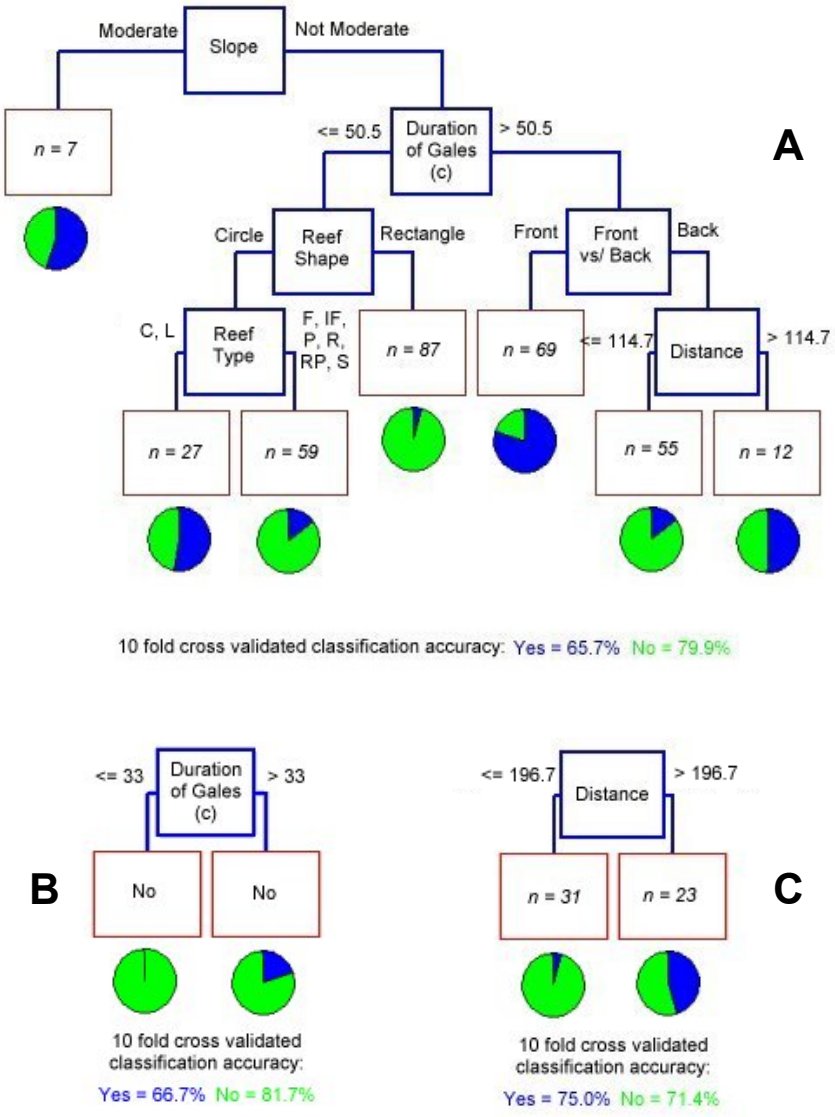



**Figure A5-13.** Classification tree fitted for the presence versus absence of trenching for cyclones: A -Ivor, Joy, and Justin, B – Ivor, and C - Justin. The relative purity of the terminal nodes and the classification accuracy indicate the success of the tree. Reef type code C = Crescentic, CF = Coastal Fringing, F = Fringing, IF = Incipient Fringing, L = Lagoonal, P = Planar, R = Ribbon, RP = Reef Patches, and S = Submerged.